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APPLIED MECHANICS REVIEWS

VOL. 8, NO. 8 MARTIN GOLAND *Editor* AUGUST 1955

NUMERICAL ANALYSIS

YUDELL L. LUKE

MIDWEST RESEARCH INSTITUTE, KANSAS CITY, MO.

INTRODUCTION

NUMERICAL analysis is the art and science of computation. It is concerned with effective and efficient methods and processes of obtaining numerical answers. Its purpose is not only the results themselves, but also the development and study of methods used to obtain the results. The techniques must be, above all else, practical. In so far as these processes and the logical arguments employed to derive them are independent of the numbers to which they are applied, numerical analysis is a branch of mathematical theory. However, the analysis must be directed to the creation of practical techniques for the numerical solution of mathematical problems. This philosophy is fundamental. Otherwise, the theory is pure and elegant but is not a contribution to numerical analysis.

Numerical analysis can be thought of as the servant of the applied scientist. Problems arising in the engineering and physical sciences, as well as the social sciences, are often complicated in nature. Derivation of the equations describing the phenomena is not the final answer, as the complexity of applied problems does not permit extraction of sufficient information, if any at all, from the equations alone. Theory must be supplemented by numerical results, followed by a physical interpretation of these results. In the final analysis, applied mathematics must ultimately reduce to numerical data.

FUNCTION OF A NUMERICAL ANALYST

The foregoing is usually regarded as a definition of numerical analysis and therefore serves to define a numerical analyst. It is not our purpose to be completely definitive, but the above conception needs enlargement if it is to adequately describe the duties and function of a numerical analyst in a scientific organization.

The body of scientific information has grown so rapidly that researchers have been forced to specialize. Applied workers can hardly be expected to have the variety of methods for solving mathematical problems at their immediate command. Frequently, assistance is required to overcome mathematical difficulties. The numerical analyst assists the applied worker by evaluating and analyzing the mathematics utilized to solve an applied problem. As a rule, the one seeking help has suddenly reached a point in his analysis demanding an unusual or nonstandard technique for its solution. To provide practical answers to such questions is an important function of the numerical analyst. Practical answers are those obtained as quickly and economically as possible, with a minimum (yet adequate) attention to rigor.

Quite often equations are in a form where a numerical solution is not feasible within the present state of the art. In this instance, the numerical analyst can suggest assumptions to simplify the analysis so that the resulting equations are manageable computationwise. In other circumstances, the functional behavior of solutions may require clarification in order to arrive at a proper physical evaluation of the problem at hand. Since applied problems reduce to numerical results, questions often center around the existence of tabular material and the direction an analysis should follow to take advantage of available numerical tables. Queries arise in all branches of mathematics; the range of topics is all-inclusive.

Rigor and strict attention to details are both desirable and necessary. In the early stages of an applied problem, however, a crude and approximate answer is often sufficient, and the epsilons and deltas can be set aside for later consideration. Emphasis on practical numerical techniques demands a different philosophy from that usually found in pure mathematics. Existence proofs, for example, play a minor role in numerical analysis. That a

AMR Transfers Editorial Operations

With this issue, the editorial operations of APPLIED MECHANICS REVIEWS will be transferred to its new offices at Southwest Research Institute, San Antonio, Texas.

For the past six years the editorial offices have been located at Midwest Research Institute, Kansas City, Mo. The help of the Institute's staff and the use of its facilities during this period have been important elements in the growth and success of the periodical. The American Society of Mechanical Engineers, and the editors, join in expressing their sincere appreciation to Midwest Research Institute for its cooperation and for its professional and financial support.

polynomial of degree n has n roots is a truism; to find the roots is the crux of the matter. Indeed, one of the problems faced by the numerical analyst is how to overcome the indifferent and sometimes hostile attitude displayed by many members of the mathematical fraternity to the subject of numerical analysis. Their help, not their antagonism, is required in this important scientific area.

ANALYSTS' REFERENCE SHELF

It has been remarked that questions put to a numerical analyst transcend all branches of mathematics. In addition to mathematical training, some knowledge of topics in theoretical and applied mechanics and physics is essential. Clearly, the most important tools of a numerical analyst are books and periodicals. In a previous article by G. E. Forsythe (1),[1] a suggested list of materials useful for a working library are outlined. At least five classes can be distinguished. They are mathematical books, books on computing machines, tables of functions, periodicals, and general references (e.g., language dictionaries). Forsythe lists about 150 titles in the category of mathematical books. It is noted that volumes are included from virtually every branch of mathematics. The portion dealing with applied mathematics lists treatises from the fields of engineering mathematics, theoretical physics, and mechanics. Though the author of the reference cited states that the listing is quite preliminary, it is a significant one, as it reveals the diversity and magnitude of information needed by a numerical analyst. Since publication of (1) there have appeared several other sources which belong on the analyst's bookshelf. First and foremost are the five volumes of the Bateman Manuscript Project (2). Other recent books are those by P. F. Byrd and M. D. Friedman (3), H. Buchholz (4), J. Meixner and F. W. Schäfke (5), and two volumes dealing with mathematical methods in theoretical physics by P. M. Morse and H. Feshbach (6).

A brief sketch of some important volumes dealing with numerical methods is offered here for those entering the field. An elementary introduction to numerical analysis is found in the volume by J. B. Scarborough (7). It has many exercises and is rewarding for the beginner. However, a number of the proofs and statements lack rigor and elegance (some are actually questionable). The text by Whittaker and Robinson (8) is more advanced and contains a wealth of information. It has gone through several editions and reprints, is often quoted, and is excellent as a working tool. The volume by J. F. Steffensen (9) covers the topics of interpolation, differentiation, and integration in a comprehensive manner. The treatment is rigorous, and strong emphasis is placed on the remainder in approximation methods.

A volume by W. E. Milne (10) is a fine and thorough presentation of the subject; numerous exercises are provided. Short mathematical tables are included to aid in the solution of problems. D. R. Hartree (11) has written an excellent treatise on numerical analysis, covering a wide range of topics. Worked examples are clearly displayed and running commentaries on the solutions offer valuable practical lessons to the computer. A recent addition to the literature is a text by A. S. Householder (12). The treatment is advanced. Basic principles of numerical analysis are well presented, but the volume suffers from a lack of numerical examples.

For numerical solution of differential equations (linear, nonlinear, partial, etc.) and associated eigenvalue problems, there is a valuable treatise by W. E. Milne (13) and two excellent volumes by L. Collatz (14, 15). See also (11).

Practical solution of systems of linear equations, inversion of matrixes, etc., is the subject of a volume by Dwyer (16). An extensive bibliography is found in two articles by G. E. Forsythe (17, 18). A collection of articles on simultaneous linear equations and eigenvalue problems has been issued in two volumes by the National Bureau of Standards (18, 19). The article by L. Fox (19) is especially important for the computer; also the material in (11) and (12) is pertinent.

The books by L. M. Milne-Thomson (20) and N. E. Norlund (21) are worthy of mention. These are for the advanced reader and both give an excellent treatment of differences, summation, and difference equations. Other topics are also considered. Norlund's volume is especially valuable as it contains an exhaustive bibliography up to 1923. A supplement to this is given in a paper by C. R. Adams (22) and covers the period to 1930. Similar listings for the past 25 years are wanting.

MATHEMATICAL TABLES

The growth of tabular material in the past decade has been phenomenal. Many important tables have been standardized and published by the National Bureau of Standards and the Royal Society Mathematical Tables Committee and their predecessor organizations. Much work remains to be done, as one finds tables dispersed all over the literature. To facilitate location of tabular material, there is the FMR (23) which should always be consulted. It is an index of tabular material up to about 1944. In 1943, the journal *Mathematical Tables and Other Aids to Computation* (MTAC) first appeared. This is the current source for information relating to mathematical tables of a universal character. It reviews all papers containing tabular material and publishes many articles on various topics in numerical analysis.

Numerous tables are associated with the name of a specific scientist, or have been identified with terms that have become standard. In this event, the sources above provide a rapid means for locating a table. However, many tables have no such nomenclature and can be listed according to mathematical function only. In this case, location of a table can be difficult. A new edition of FMR, contemplated for about 1956, should correct this deficiency. It has also been suggested that MTAC periodically publish an index listing new tabular material according to function (24). In this fashion MTAC could keep current the new edition of FMR and so facilitate compilation of future indexes.

In technical work, there is a continuing need for desk computation and so, also, for mathematical tables. In the exploratory, research, and planning stages of a problem, it is important to know the qualitative behavior of a function. Desk calculation is a proving ground for new types of problems to be ultimately placed on an automatic computer. Tables are needed for a preliminary survey of a problem. Here entries can be widely spaced and given to a few decimal places (this is known as a "low accuracy" table). It is the opinion of many that high-speed computation has increased, rather than decreased, the need for mathematical tables.

Automatic calculation requires a different type of table than does desk calculation. With the present state of the art, internal storage of tables is not desirable, since scanning or table look-up followed by interpolation is not an economical usage of the equipment. Algorithms are needed, and sufficient tabular values should be available to serve as a check. High-speed computation appears to be changing the character of mathematical tables required, but has not altered their need.

Applied research demands more tables, but one of the difficulties is that of publication. No doubt many useful tables are lost through irregular publication or lie buried in progress reports; tables appear in widely dispersed and sometimes unfamiliar sources. There is need for financial support not only for production of tables, but also for their publication.

Short tables should be collected together in a single volume or

[1] Numbers in parentheses indicate References at end of paper.

volumes. The volume of tables by Jahnke-Emde (25) have long been popular as a guide in the planning stages of a problem. Further work along this line is urgently needed. It is encouraging to note that the National Bureau of Standards has accomplished some work in this direction (26).

Many new tables make their appearance in applied papers, and eventually some of these should be collected in volumes of the type just mentioned. It has been found that, in many instances, tables need editing, checking, and recomputing, since sufficient information on what is tabulated, its accuracy, etc., is not furnished. Applied workers can facilitate future table making and production by following a few simple steps. With the appearance of a table, one should describe the method of computation, references to related tables, method of checking, interpolatory accuracy, etc. All too often descriptive material is not lucid. The writer has seen tables of continuous functions computed to high accuracy (8 to 10 decimal places), yet information pertinent to interpolation is wanting. This, the user must discover, usually by differencing. But differencing is a standard technique for checking a table and should have been done and reported by the table maker, thus saving duplication of effort. Editors and referees should insist on discussions of the type outlined.

Tabulation of univariate or bivariate tables is usually not difficult. The problem for the future is tabulation of multiparameter functions; e.g., the hypergeometric function. Systematic tabulation is not the answer, as the space requirement and cost of publication can become prohibitive. Separation of the variables seems to be a fruitful idea. For example, can we express a three parameter function as a function of two two-parameter functions? There is no general theory available, and further analytical work in this direction is needed.

FUTURE PROBLEMS

The types of mathematical problems encountered in the solution of applied problems are well known. What of the problems for the numerical analysis of the future? There are many unsolved problems, or rather problems to which we do not know the answer. Some have been indicated. For a discussion of these and others see (24) and the papers by Rosenhead, Fletcher, and Young (27), who discuss the influence of computation on society. An excellent discussion of some technical problems for the future is given in a publication of the National Bureau of Standards (28).

ORGANIZATION OF AN APPLIED MECHANICS GROUP

The writer has had considerable experience in the organization and operation of an applied mathematics group in a research organization, and some remarks in this direction may be of interest. This is essentially the subject of a previous paper by the author (29). It is pertinent to augment the ordinary scientific facility with a theoretical group which works integrally with the experimental phases. The group is normally composed of applied workers who are well trained in the physical sciences such as mechanics, elasticity, dynamics, etc. They have the responsibility of conducting a theoretical analysis of a problem and of mapping out the direction further analytical and experimental work should follow. It is not necessarily efficient that the analyst also undertake the numerics attendant to the solution of an applied problem. Thus an important adjunct of an applied mathematics section is a computation group. This latter group is closely coordinated with the analytical and experimental studies, and has the responsibility to evaluate and analyze the mathematics an applied worker employs in the solution of a problem. This integrated effort, when properly utilized, can greatly reduce the cost and effort required to find the solution to research and development problems.

It is found that a large majority of the tasks of the computation group can be handled by personnel with a bachelor's degree but having at least a minor in mathematics. Personnel with less training are not suitable. Though much of numerical work is routine, a computer can and must be trained to use initiative and resourcefulness in the solution of mathematical problems. To this end, a mathematical background of the type indicated is requisite.

Unfortunately, too few universities offer adequate courses in numerical analysis, although the situation is improving. Academic training, therefore, must at present be supplemented by an in-training program. This includes individual instruction as well as group instruction in the form of seminars. The latter are held periodically and constitute a semiformal, planned course in applied mathematics and numerical analysis.

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BAULE, B., Die Mathematik des Naturforschers und Ingenieurs Bd. I. Differential- und Integralrechnung, 9th ed., Leipzig, S. Hirzel Verlag, 1954, viii + 187 pp., 183 figs. DM 7 (paperbound).

BESICOVITCH, A. S., Almost periodic functions, New York, Dover Publications, Inc., 1954, xiii + 180 pp. $1.75 (paperbound).

DUBS, F., Aerodynamik der reinen Unterschallströmung, Basel, Stuttgart, Verlag Birkhäuser, 1954, 225 pp., 178 figs. SFr. 22.

FINCK, J. L., Thermodynamics from the classic and generalized standpoints, New York Bookman Associates, 1955, xv + 224 pp. $7.50.

HIGDON, A., AND STILES, W. B., Engineering mechanics, 2nd ed., New York, Prentice-Hall, Inc., 1955, xix + 585 pp. $7.95.

JEANS, SIR JAMES, The dynamical theory of gases, 4th ed., New York, Dover Publications, Inc., 1954, 444 pp. $2 (paperbound).

KOGAN, L. A., Moderne Technologie der Verlademaschinen und Kräne (translated from Russian), Berlin, VEB Verlag Technik, 1953, 123 pp.

MENZEL, D. H., edited by, Fundamental formulas of physics, New York, Prentice-Hall, Inc., 1955, xxxv + 765 pp.

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PEROW, W. A., AND BRAND, W. J., Feinmahlen der Erze (translation from Russian), Berlin, VEB Verlag Technik, 1954, 190 pp.

RAŠKOVIC, D., Zbirka zadataka iz otpornosti materijala. I. II, Beograd, Naukna Kniga, 1955, 1952, vii + 258 pp., 132 pp.

ROSSINI, F. D., editor, Thermodynamics and physics of matter (High Speed Aerodynamics and Jet Propulsion, Vol. I), Princeton, N. J., Princeton University Press, 1955, xviii + 812 pp. $15.

ROUTH, E. J., Advanced part of a treatise on dynamics of a system of rigid bodies, 6th ed., New York, Dover Publications, Inc., 1955, xiv + 484 pp. $1.95 (paperbound).

SCHLEGELMILCH, W., Die Differentialoperationen der Vektoranalysis und ihre Bedeutung in Physik und Technik, Berlin, VEB Verlag Technik, 1954, xi + 254 pp.

SCHNEIDER, P. J., Conduction heat transfer, Cambridge, Mass., Addison-Wesley Publishing Co., Inc., 1955, xi + 395 pp. $12.50.

SPALDING, D. B., Some fundamentals of combustion (Gas Turbine Series, Vol. II), New York, Academic Press, Inc.; London, Butterworths Scientific Publications, 1955, x + 250 pp. $7.50.

WECHMANN, A., Auswertung Gewässerkundlicher Messergebnisse, Berlin, Verlag Technik, 1952, 99 pp. DM 10.

Letters to the Editor

2198. Re AMR 8, Rev. 1005 (April 1955): Braun, I., The momentum equations of the Reiner liquid.

The name "Renier" should read "Reiner" in both title and first line of review.

The editors regret this error.

2199. Re AMR 8, Rev. 313 (January 1955): W. Lewicki, Hydrodynamic lubrication of roller bearings.

The reviewer wishes to revise the last paragraph of this review which stated that calculations made by the author with regard to the coefficient of rolling friction appeared incorrect due to the omission of a component of the normal force. The author actually calculated the friction resistance in terms of the viscous drag on the roller and plane on the assumption that the axis of the roller is stationary. It is agreed that this will give an estimate of the rolling friction, although some of the assumptions made by the author are perhaps open to question. W. Richmond, USA

2200. Re AMR 8, Rev. 43, (January 1955): G. F. Miller and H. Pursey, The field and radiation impedance of mechanical radiators on the free surface of a semi-infinite isotropic solid.

In connection with the above review, the authors feel the following comments are in order:

Our essential contribution to the theory, namely, the evaluation of the field at infinity at points within the solid, appears to have escaped the attention of the reviewer. Reissner, of whose important work we were admittedly unaware, has obtained the result only in the comparatively trivial case (*d*). The complex integral representations for displacement components are derived only as a preliminary to their evaluation. and the method is duly ascribed to Lamb. G. Miller, England
H. Pursey, England

2201. Re AMR 8, Rev. 1094 (April 1955): W. R. Sears, General theory of high speed aerodynamics.

In connection with the above review, the following statement is made: "On p. 587 we read finally with amazement: 'The velocity of sound (for the general case) depends on the direction of the line along which it is computed.' How shall the sound waves then know how to govern themselves? Let no one think that the velocity of sound may in any way depend on the direction of the sound waves. It does not." The words in parenthesis are included in the text and have been omitted in the review.

I want to make clear that the original statement is correct. The chapter deals with flow of hyperbolic type where viscosity and conductivity are neglected (see, for example, p. 585). With the assumption, discontinuities in the flow are found, where the speed of sound is not single-valued. For example, at the point of intersection of two shocks five different values of the speed of sound can be defined; each value is related to a given region of the flow field. Points on the shocks or contact discontinuities can be analyzed by means of the method of characteristics. There it is necessary to specify the value of the speed of sound used in the equations, and therefore it is necessary to define the direction of the line along which the speed of sound is considered. The statement that in such flow "the velocity of sound for the general case depends on the direction of the line along which it is computed" is correct although it appears amazing to the reviewer.

A. Ferri, USA

Theoretical and Experimental Methods

(See also Revs. 2233, 2236, 2247, 2251, 2252, 2255, 2273, 2275, 2286, 2287, 2292, 2298, 2318, 2342, 2403, 2405, 2410, 2417, 2456, 2459, 2463, 2519, 2567, 2570, 2577)

2202. Reddick, H. W., and Miller, F. H., Advanced mathematics for engineers, 3rd ed. (revised by Miller, F. H.), New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, xiv + 548 pp. $6.50.

The book under review is a revision of the second edition by

Prof. F. H. Miller. Among the changes that have been made are: the number of problems has been increased by more than 20%; Legendre's equation has been added and the physical applications of Legendre's polynomials are discussed; numerical methods for solving differential equations have been introduced; and a section on Laplace transforms has been added. Otherwise, the plan and features of the first and second editions have been retained. Answers to all problems are given in the back of the book.

It appears to the reviewer that the treatment of operational calculus by considering all three methods, namely, those of Heaviside, Bromwich's line integrals, as well as Laplace transforms, is superfluous. The last-named method employing the complex inversion theorem would be sufficient.

The student desiring to know how to use mathematics in the practice of engineering will find this text a useful one.

E. J. Scott, USA

2203. Collatz, L., Numerical treatment of differential equations [Numerische Behandlung von Differentialgleichungen], 2nd rev. ed. (Grundlehren der mathematischen Wissenschaften, Bd. 60), Berlin, Springer-Verlag, 1955, xv + 526 pp., 118 figs. DM 56.

For a review of first edition see AMR **6,** Rev. 1598. Present tome is similar in subject matter. A chapter (now called chap. I) has been added. This brings together mathematical principles and aids useful for the exposition of chapters which follow. New material added throughout the book bears heavily on subject of error control and stability and includes contributions of workers in the period 1950–1954. Importance of text cannot be overemphasized. It contains the most thorough and comprehensive treatment of numerical methods for the solution of differential equations (ordinary, partial, integral, etc., and associated eigenvalue problems) that has been published. Text is well documented with numerical examples, and questions relating to error and stability are covered in great detail and with an emphasis the subject deserves. Y. L. Luke, USA

2204. Fox, L., A note on the numerical integration of first-order differential equations, *Quart. J. Mech. appl. Math.* **7,** part 3, 367–378, Sept. 1954.

The difficulties encountered in solving first-order equations by central difference formulas are explained and exemplified. The unreliability of the solution differences, due to the presence of an oscillating term, makes it unsafe to use corrections. The best possible way of obtaining an equivalent second-order equation, conveniently solved by relaxation, is explained.

M. G. Salvadori, USA

2205. Uno, T., On some systematic method for finding limit cycles, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 513–516.

Author considers family of differential equations represented by $dy/dx = (AY + BX)/(CY + DX)$, or

$$\begin{bmatrix} \dot{y} \\ \dot{x} \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} Y\,(x,y) \\ X\,(x,y) \end{bmatrix} = T \begin{bmatrix} Y \\ X \end{bmatrix}$$

For $AD-BC = 1$, it is shown that, under certain conditions, the trajectories of the solutions in the x,y-plane may be given a "local ordering" in terms of the parameters of T. A particular case considered is when T depends only on one parameter θ, with $A = D = \cos\theta$ and $B = -C = \sin\theta$. The types of limit cycles which can occur about a focal point of the system are described, and the idea of the local order is applied to show the effects of variation of θ on these limit cycles. A. A. Schy, USA

2206. Woods, L. C., A note on the numerical solution of fourth order differential equations, *Aero. Quart.* **5,** part 3, 176–184, Sept. 1954.

Equation studied is the biharmonic $\nabla^4 w = k(x,y)$. Following A. Thom ["Arithmetical solution of equations of the type $\nabla^4\psi$ = constant," *Rep. Mem.* 1604, 1933], author introduces an intermediate function $\theta(x,y)$ so that $\nabla^2 w = \theta$, $\nabla^2\theta = k$. Paper develops a relaxation technique to solve latter simultaneous equations. Advantage of this procedure over a direct relaxation of biharmonic lies in a greater rate of convergence. Numerical solution of viscous flow equation is briefly discussed. For a practical example, calculations are shown for the deflection of a thin square plate, clamped at its edges and loaded uniformly on one face.

Y. L. Luke, USA

2207. Nishimura, T., On a new method of finite differences for solving differential equations, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 303–304.

Author exhibits several approximation patterns useful in the solution of the partial differential equations $\nabla u = f(x,y)$, $\nabla^2 u = f$, etc. R. E Gaskell, USA

2208. Petrovsky, I. G., Lectures on partial differential equations (translated from Russian by A. Shenitzer), 1st English ed., New York, London, Interscience Publishers, 1954, x + 245 pp. $5.75.

Book is an English translation of one reviewed previously [AMR **5,** Rev. 1615]. Present edition appears to differ from original only by the addition of a short foreword by R. Courant and a translator's note.

The contents are well described by the cited review and need not be repeated except to note that there is no index (detailed list of contents helps to overcome this deficiency). Reviewer adds only that the translation must be exceptionally well done if one may judge by the clarity of expression, continuity of thought, and smoothness of reading. Availability of this book in the English language helps to close a broad gap by providing engineers with an introduction to an important field of study while maintaining a high degree of rigor and comprehensibility. No person working with the mechanics of continua should be without this volume. H. N. Abramson, USA

2209. Diaz, J. B., and Ludford, G. S. S., On two methods of generating solutions of linear partial differential equations by means of definite integrals (Note), *Quart. appl. Math.* **12,** 4, 422–427, Jan. 1955.

Paper compares the methods of Bergman and Le Roux for the case of linear hyperbolic equations in two variables. A theorem which is the basis for Bergman's method in this case is proved. Object of paper is to show that this theorem is a restatement of results of Le Roux and that in the application to fluid dynamics Le Roux's method is simpler. J. D. Riley, USA

2210. Van den Dungen, F. H., Accuracy of numerical integration (in French), "Studies in Mathematics and Mechanics" (Presented to R. von Mises by Friends, Colleagues, and Pupils), Academic Press, Inc., New York, 103–110, 1954.

Author discusses the propagation of errors which arise in the solution of the one-dimensional Cauchy problem by the method of finite differences. Let $u(t,x)$ be a solution of the wave equation such that $u(0,x)$ vanishes outside the interval $x_1 - x_2$, then

$$F(t) = \int_{-\infty}^{+\infty} e^{ipx}\, u(x,t)dx = \sum_n [(ip)^n/n!]\, V_n(t)$$

where the quantity

$$V_n(t) = \int_{x_1-ct}^{x_1+ct} x^n u(x,t)\,dx$$

is a "variant integral." The author shows that analogous expressions exist for the finite difference equation corresponding to the one-dimensional wave equation except that the integrals in the above are replaced by summations. Using the fact that the propagation of error in a Cauchy problem is itself a Cauchy problem, he then calculates from the corresponding variants the time dependent error moments. Furthermore, by equating the coefficients of like powers of p in the analogs of the above expressions he is able to derive directly the solution which the finite difference technique approaches at points near the origin.

R. D. Spence, USA

2211. Grunsky, H., A method for the solution of initial value problems for ordinary and partial linear differential equations of the second order (in German), *ZAMM* **34**, 8/9, 291–292, Aug./Sept. 1954.

Author gives iterative procedures for solving first order ordinary equations with boundary condition $y = y_0$ at $x = x_0$; second-order ordinary equations with conditions $y = y_0$ and $dy/dx = y_0'$ at $x = x_0$; and second-order hyperbolic partial differential equations in normal form

$$u_{xy} + a_1(x,y)u_x + b_1(x,y)u_y + c_1(x,y)u = 0$$

with conditions $u = \alpha(x)$ for $y = y_0$, $u = \beta(y)$ for $x = x_0$.

Convergence is discussed, but no examples are given to illustrate the rapidity of convergence in practical cases.

J. T. Stuart, England

2212. Tea, P. L., A string-net analog for the numerical solution of the equations of Laplace and Poisson, *J. Franklin Inst.* **258**, 4, 287–304, Oct. 1954.

Laplacian operator is replaced by second-order difference equation as in ordinary relaxation procedures. String net contains boundary, and at every nodal point equilibrium position of string segments emanating from node satisfies above difference equation at that node. Several examples are treated, including rectangular and curved boundaries. Device is useful to solve title equations with various boundary conditions, as latter are easily represented by weights attached to the strings. Accuracy is sufficient for many engineering problems. For another mechanical device to solve problems involving the Laplacian operator, see AMR **3**, Rev. 1212. Y. L. Luke, USA

2213. Pólya, G., Estimates for eigenvalues, "Studies in mathematics and mechanics" (presented to R. von Mises by Friends, Colleagues, and Pupils), Academic Press, Inc., New York, 200–207, 1954.

Author makes several general remarks on the Poincaré eigenvalue theorem as applied to the membrane problem. He suggests that solutions of the membrane problem in the domain D which are transplanted to the domain Δ by a linear transformation of coordinates may well serve as suitable functions from which to calculate the upper bounds of the eigenvalues in Δ. In the last section of the paper he examines the possibility that the method of finite differences yields lower bounds for the eigenvalues.

R. D. Spence, USA

2214. Radok, J. R. M., The solution of eigenvalue problems of integral equations by power series (Note), *Quart. appl. Math.* **12**, 4, 413–417, Jan. 1955.

The eigenvalue problem for an integral operator whose kernel $K(x,y)$ is a homogeneous polynomial $P(x,y)$ for $0 < y < x < 1$ and $K(x,y) = P(y,x)$ for $0 < x < y < 1$ is solved by a power series method. The case $P(x,y) = x - y$ is worked out in detail. It is remarked that the method is applicable for any kernel of finite rank. H. D. Block, USA

2215. Kharkeevich, Yu. F., Graphic solution of integral equations (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **15**, 207–215, 1953.

Author considers some geometrical interpretations of a solution of Fredholm's and Volterra's linear integral equations of the second kind. Then, by means of these interpretations, he gives a manner of graphical solution of these equations.

Author uses the method given by A. B. Shtykan in his article "Geometrical methods of solution of some problems of mathematical analysis," title source, **13**, 1952.

At first the author gives construction of the integral of the product of two functions

$$y = \lambda \int_{s_0}^{s} K(s)f(s)ds$$

Then using this construction he constructs successive approximations for the solution of the following equations

$$\varphi(x) = f(x) + \lambda \int_a^b K(x,s)\varphi(s)ds \qquad \text{Fredholm}$$

$$\varphi(x) = f(x) + \lambda \int_a^x K(x,s)\varphi(s)ds \qquad \text{Volterra}$$

Then he applies this method to graphical solution of the homogeneous integral equation with symmetric kernel.

T. F. Riabokin, USA

2216. Shtykan, A. B., Graphic methods for the solution of integral equations (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **15**, 216–222, 1953.

Author gives graphical method for solution of Fredholm's and Volterra's nonlinear integral equations with the kernels of type

$$K(x,s) = \sum_{i=1}^{i=n} \psi_i(x)\varphi_i(s) \quad (i = 1 \ldots n)$$

He considers Fredholm's nonlinear integral equation

$$u(x) = f(x) + \int_a^b K(x,s)\,[u(s)]^n ds \quad (n = 1,2\ldots)$$

and Volterra's nonlinear integral equation

$$u(x) = f(x) + \int_0^x K(x,s)/\mu[u(s)]ds$$

with kernels

$$K(x,s) = \sum_{i=1}^{i=n} \kappa_i[\psi_i(x)]\ \chi_i(s) \quad (i = 1 \ldots n).$$

T. Riabokin, USA

2217. Tables of functions and of zeros of functions, *U. S. Dept. Comm., Nat. Bur. Stands., appl. Math. Ser.* **37**, ix + 211 pp., 1954. $2.25.

Volume collects 18 short tables by various staff members of the National Bureau of Standards (NBS) Computation Laboratory and its predecessor organization. Three tables are published here for the first time. The others have appeared in various journals. Reprints have been exhausted and, to meet a continuing demand, tables have been brought together in a convenient form. Space does not permit naming of each table, but following is a partial list to give idea of contents. Volume includes tables of integrals of Bessel functions $J_0(x)$ and $Y_0(x)$, Struve functions, Fourier coefficients, $x^n/n!$, zeros and weight coefficients for Legendre and Laguerre polynomials, zeros of certain Bessel functions of fractional order, etc. Growth of tabular ma-

terial in recent years has been phenomenal. Volume is of the Jahnke-Emde type which is well known and popular. More collections of this kind are needed. They are convenient for use in the planning and exploratory stages of a problem, and the need for consulting widespread sources is reduced. It is heartening to learn NBS contemplates further work in this direction.

Y. L. Luke, USA

2218. Table of the gamma function for complex arguments, *U. S. Dept. Comm., Nat. Bur. Stands., appl. Math. Ser.* 34, xvi + 105 pp., 1954. $2.

Function is of basic importance in pure and applied mathematics. Solution to many problems in difference and differential equations depends on gamma function. Present work permits tabulation of many functions such as the hypergeometric function for complex values of the parameters. Function of complex argument has found application in atomic and nuclear physics; e.g., the Fermi function, and Coulomb wave functions. Short tables of title have appeared in several scattered sources, but this is the first large scale tabulation. Volume gives to 12d real and imaginary parts of $\log e\Gamma(z)$; $z = x + iy$; $x,y = 0(0.1)10.0$. Values of $\Gamma(z)$ in other three quadrants can be readily determined from present table. To facilitate computation, tables of circular and hyperbolic functions of argument πx, $x = 0(0.1)10$ are appended. Introduction gives properties of functions, method of computation, techniques for interpolation and inverse interpolation. A schedule is presented showing number of decimals obtainable using n-point interpolation in the x and y-direction. An excellent bibliography is included. Y. L. Luke, USA

2219. Matsukura, K., On a solution of equations containing general polynomials with numerical coefficients and certain transcendental functions by expanding their roots into infinite series, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 295–298.

Author sets $y = f(x)$ and represents the inverse function by $x = g(y)$. With restrictions regarding differentiability and single-valuedness, he then writes

$$g'(y) = 1/f'(x),\ g''(y) = -f''(x)/[f'(x)]^3, \text{ etc.}$$

And further, by Taylor's theorem

$$g(0) = g(y_1) - y_1g'(y_1) + y_1^2g''(y_1)/2 \ \ldots.$$

Now if x is a root of $f(x) = 0$, then $x = g(0)$. Author uses this series, then, to arrive at an approximate value of the root. Several examples conclude the article. R. E. Gaskell, USA

2220. Jeffreys, H., What is Hamilton's principle? *Quart. J. Mech. appl. Math.* **7,** part 3, 335–337, Sept. 1954.

In nonholonomic systems the so-called work function does not express the whole of the forces acting; the Hölder-Voss modification of Hamilton's principle allows correctly for this fact.

From author's summary

2221. Young, A., Techniques for the summation of products on Hollerith and National accounting machines, *Quart. J. Mech. appl. Math.* **7,** part 2, 136–151, June 1954.

Methods of evaluating sums of products applicable to numerical quadrature, Fourier analysis, and synthesis, evaluation of serial correlations, and other computations with punched-card equipment are described. One method is new. Also given are modifications required for making the methods applicable for use with National accounting machines. Emphasis is placed throughout on most economical use of machines and on incorporation of checks.

From author's summary by C. C. Gotleib, Canada

2222. Bodewig, E., A practical refutation of the iteration method for the algebraic eigenproblem, *Math. Tables Aids Comput.* **8,** 237–240, 1954.

Author states the thesis that, in general practice, even when only the largest latent root of a matrix is required, it is less economical to apply the method of iteration than to find the characteristic equation explicitly and solve. In illustration he exhibits a pathological case of a 4×4 symmetric matrix for which the 1200th iteration gives only about four-decimal accuracy. The illustration is of some interest but the practical issues are much more complicated. Such pathological cases may be exceedingly rare in practice, and in any event there are known methods for accelerating iterations and for separating close latent roots which the author seems not to have tried [see J. H. Wilkinson, in the following review, for a review of extensive experience and a summary of a number of devices]. However, for matrixes small enough to be stored in the machine, or to be treated by hand, iteration probably has little to recommend it except simplicity.

A. S. Householder, USA

2223. Wilkinson, J. H., The calculation of the latent roots and vectors of matrixes on the pilot model of the A.C.E., *Proc. Camb. phil. Soc.* **50,** 536–566, 1954.

Since the A.C.E. has no auxiliary storage, and only 361 words of fast storage, there was virtually no alternative to the use of iterative methods for finding latent roots. This paper summarizes very considerable experience at the National Physical Laboratory in the use of such methods for solving the latent-root and vector problem with unsymmetric as well as with symmetric matrixes. Many will be interested in the statement, made and emphasized, that even for matrixes of order 50 or more it is possible to get all the roots without serious loss in accuracy and, indeed, with greater accuracy than was attained by any other method tried.

The author begins by discussing the case of a real dominant root; acceleration by iterating with $A - \mu I$ instead of A; the use of matrix squaring; the Hestenes-Karush iteration; rotational diagonalization of a symmetric matrix; and a method of improving an approximate set of latent vectors. Next he comes to the determination of nondominant roots, first giving methods of removing components of known latent vectors (recommended when the original matrix has many zeros and is best retained intact), and second, methods of reducing the order of the matrix as each root and vector are found. For complex roots and vectors, one may obtain the real quadratic satisfied by a pair of conjugate complex roots, thereafter obtaining the corresponding pair of vectors. Otherwise one may iterate with $A - i\mu I$ for suitable μ. The reduction of the matrix raises certain special problems in the complex case, which the author deals with.

The theoretical discussion accounts for about two thirds of the paper, and the rest concerns programming. One series of codes was prepared for dealing with small matrixes that can be held in the internal storage; another is used for larger matrixes and calls for reading in the matrix from punched cards with each iteration. Double precision products are accumulated and only the sum is rounded. Provision is made for applying Aitken's δ^2-process from time to time when convergence is slow. Provision is made also for adjusting μ and iterating with $A - \mu I$ to accelerate convergence. Careful attention is given to scaling in order to avoid the use of floating point.

The short list of references omits the sources of several of the techniques presented [e.g., the rotational diagonalization discussed by Jacobi, *J. reine Angew. Math.* **30,** 51–94, 1864; note that the first reference in the list is dated 1952 and should be 1926]. Nevertheless, the paper is essentially self-contained, and forms a valuable contribution to the subject.

A. S. Householder, USA

2224. Anonymous, Mechanical differential analyser, *Ball Bearing J.* no. 3, 67–72, 1953.

2225. Strong, J. D., A practical approach to analog computers, *Instrum. and Automat.* **28,** 4, 602–610, Apr. 1955.

2226. Hovious, R. L., Morrill, C. D., and Tomlinson, N. P., Industrial uses of analog computers, *Instrum. and Automat.* **28,** 4, 594–601, Apr. 1955.

2227. Rose, A., and Johnson, R. C., Computers, statistics, and mathematics, *Indust. Engng. Chem.* **47,** 3, part II, 626–632, Mar. 1955.

Third annual review.

2228. Funke, L., The calculus of variations as an auxiliary means for the design engineer (in German), *Forsch. Geb. Ing.-Wes. (A)* **19,** 4, 115–122, 1953.

In a water supply system, required amount of flow Q at each point of the system as well as the required water head h at each end point are given. Problem is to determine the pipe diameter D at each point in such a way that the total operating cost K per year will be minimum. Operating cost of the pump depends on the head loss, which is the accumulation of the elementary head loss along the pipeline, (const) $Q^{1.9}\,D^{-4.9}dx$. On the other hand, the yearly cost of the piping per unit length is proportional to D. Thus K is the sum of a constant, an integral whose integrand is proportional to $D^{-4.9}$, and another integral whose integrand is proportional to D. Besides, if there are u end points at each of which the water head is prescribed, then we have $u - 1$ side conditions. To minimize K under these side conditions, we first get a set of solutions including Lagrange multipliers, which are then determined by the side conditions. A simple numerical example is given. The case of a system containing a closed circuit in it is also discussed. Author states the same method will also be applicable to a gas supply system and a low-voltage city line system of electricity.

Reviewer believes it will be simpler and more adequate to assume from the outset that D be a constant along each branch of the system if one so desires at the end, as the author does in the given example. But this will reduce the problem to one within the reach of the differential calculus rather than the calculus of variations. S. Moriguti, Japan

2229. Köbler, E. L., with the cooperation of Legat, A., English-German and German-English dictionary for the iron and steel industry [Englisch-deutsches und deutsch-englisches Wörterbuch für die Eisen- und Stahl-Industrie], Wien, Springer-Verlag, 1955, xii + 168 pp. + 162 pp. DM 28 ($6.65).

Book contains 8500 entries referring to title and related fields. Ed.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2205, 2220, 2277, 2310, 2311, 2448, 2570)

2230. Bouligand, G., Rational mechanics. Lectures and solved problems for the use of students of the faculty of sciences. [Mécanique rationnelle. Cours et problèmes résolus à l'usage des élèves des facultés des sciences], 5th ed., Paris, Librairie Vuibert, 1954, xxxii + 572 pp. 2400 francs.

This is a course on mechanics in the French tradition, which changes with time but retains its attention to clarity and detail in a certain fundamental classical field. There is hardly any statics, vectors are used where convenient, Lagrange's equations appear early (p. 72) and are used extensively, Hamilton's equations and Cartan's integral invariants are discussed, three chapters are devoted to the mechanics of continua, and there is a brief chapter (16 pp.) on relativity which leads the reader to the Schwarzschild field and the rotation of perihelion. The plan of the book is indicated by the chapter headings of part I: 1. Theory of vectors. 2. Kinematics. 3. Geometry of masses and kinetics. 4. Principles and general theorems of dynamics. Applications to the solid body. 5. Elements of analytical dynamics. 6. Usual cases of integration. Stability. Small movements. Principle of least action and applications. 7. Shocks and percussions. 8. Problems of dynamics without friction. 9. Supplementary material on analytical dynamics. 10. Mechanics of strings. 11. Deformable media. 12. Mechanics of fluids. 13. Velocity of light, spacetime, gravitation. Part II is devoted largely to a careful treatment of the classical theory of friction, including the collision of rough bodies. Throughout the book there are a great many particular problems, most of them worked out, the intention being to give readers (including those who work alone) a thorough familiarity with the field. There is an index, but it is not, in the opinion of the reviewer, sufficiently detailed, and reference to pages, rather than to paragraphs, would have made it easier to use.

J. L. Synge, Ireland

2231. Halaunbrenner, M., The concept of anisotropic friction in light of experimentation (in Polish), *Przegl. mech.* 13, 3, 81–85, Mar. 1954.

The anisotropic frictional force depends upon direction of motion of a sliding body on another surface. The directional variations of these forces are observed either in nonisotropic bodies or due to asperities formed by various types of machining of the surfaces. The experimental work conducted by author concerns the latter type of anisotropic friction. The variation of transverse μ_p and longitudinal μ_w coefficients of friction, with variation of direction of motion of a sliding body to the direction of asperities, has been found for various cases of Cr-Ni steels as-machined sliding on steel-as-machined.

The following conclusions can be drawn: (1) The deviation ψ of sliding to the direction of acting force is small; its maximum does not exceed 4°; (2) on the average, $\mu_w = 10\,\mu_p$; (3) ψ and μ_p are independent from the frictional area; (4) the difference between μ_w and μ_p decreases with increase of velocity of a sliding body; (5) no anisotropic frictional effect was observed in case of one surface being polished; (6) the anisotropic frictional force is a combination of two phenomena: adhesive force between two bodies in contact, and a mechanical force due to interlocking of asperities of surfaces. The idea of determination of separate effects of these two forces is being studied.

R. M. Evan-Iwanowski, USA

2232. Whitton, P. W., and Ford, H., Surface friction and lubrication in cold strip rolling, *Instn. mech. Engrs.*, 12 pp., 2 plates, 1954.

In cold rolling, the coefficient of friction μ can be determined by applying a back tension to the strip. This value shall be so large that the neutral point is forced to the exit, so the friction will have the same direction all over the opening between the rolls. In this way, for the coefficient of friction

$$\mu = T/P \cdot R$$

wherein P is the measured force, R is the radius of the rolls, and T the measured roll torque. By this method the coefficient of friction μ was determined for rolling of strips of mild steel, copper, brass, and aluminum without lubrication and with lubrication by different oils as follows:

	μ without lubrication	μ with lubrication
Steel strips on smooth rolls	0.085	0.038–0.080
Copper strips on smooth and rough rolls	0.070–0.093	0.046–0.075
Brass on smooth rolls	0.093	0.043–0.067
Aluminum strips on smooth rolls	0.092–0.101	0.049–0.087

By application of lanolin as lubricant the coefficient of friction decreased for rolling of aluminum strips to $\mu = 0.025$. The repeatability of the results was satisfactory.

Using the measured μ values in the sense of the theory of Bland and Ford, a good agreement was brought out between the measured and calculated values of rolling force and rolling torque.

E. Siebel, Germany

2233. Steinberg, T. S., On periodic solutions of a differential equation of nonlinear oscillations in the presence of "dry" and "viscous" friction (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* **1954,** 4, 13–22, 1954.

The equation under discussion is

$$\ddot{x} + 2n\dot{x} + k^2x = \delta m + \psi(x,\dot{x}) \qquad [1]$$

where m, n are constants which may take any sign, k is a constant assumed positive, and $\psi(x, y)$ is a function satisfying a Lipschitz condition in any bounded region which does not include the x-axis. As for δ

$$\delta = \begin{cases} +1 \text{ for } \dot{x} < 0 \text{ or } \dot{x} = 0,\ x > 0; \\ -1 \text{ for } \dot{x} > 0 \text{ or } \dot{x} = 0,\ x < 0 \end{cases}$$

The presence of the term δm and of the terms depending on x is due to the presence of both dry and viscous friction in the system.

Take first the system with $\psi = 0$ in the form

$$\dot{x} = y, \quad \dot{y} = -k^2x - 2ny + \delta m \qquad [2]$$

It is readily shown that for $k^2 > n^2$, [2] has a periodic solution which depends on a certain positive constant

$$a = -mk^{-2} \operatorname{cth} (n\pi/2\omega), \quad \omega = (k^2 - n^2)^{1/2}$$

so that $mn < 0$. Let $y = f(x, a)$. The system $cy = f(cx, a)$ is shown to be "topographic" in the sense of Poincaré and, by means of it, the periodic solution Γ obtained is shown to be unique. When $|\psi|$ is sufficiently small it is shown that Γ is contained in a ring which the solutions of

$$\dot{x} = y, \quad \dot{y} = -k^2x - 2ny + \delta m + \psi(x, y) \qquad [3]$$

(equivalent to [1]) only penetrate. Hence (Poincaré and Bendixson) [3], and hence [1], possess a unique periodic solution. Actual bounds are produced for $|\psi|$. Applications are made to the cases $\psi = g\delta\,|\dot{x}|^{p}x^{2q}$, g and p real, $p > 0$, q a positive integer, and $\psi = \delta^{p+1}(g_1x^p + g_2\dot{x}^p)$, g_1 and g_2 constants, p a positive integer.

S. Lefschetz, USA

2234. Bottema, O., Kinematics of frictional rolling (Rollgleiten) (in German), *Arch. Math.* **6,** 1, 25–28, 1954.

Frictional gliding (Rollgleiten) is defined as the process of one plane curve c moving upon another plane curve C (assumed fixed in space) in such a way that they always are tangent and that their arcs s and S, which have been in contact between the time $t = 0$ and an arbitrary time t, have a constant, time-independent ratio $\lambda = S/s$. Author solves and discusses the problem of finding curves c and C for a given motion of two planes and a given λ.

H. L. Oestreicher, USA

2235. Wolford, J. W., and Nicklas, J. C., Linkage design techniques, *Prod. Engng.* **25,** 12, 133–139, Dec. 1954.

Comparison is given of four methods—two approximate and two exact—for construction and design of four-bar linkages that generate a path passing through given points.

From authors' summary

2236. Rosenauer, N., Complex variable method for synthesis of four-bar linkages, *Austral. J. appl. Sci.* **5,** 4, 305–308, Dec. 1954.

In the equation $ae^{i\theta_1} + be^{i\theta_2} - ce^{i\theta_3} - de^{i\pi} = 0$, which expresses the fact that a plane four-bar linkage is closed, each term represents the length and position of a bar. By differentiating twice with respect to time, two other equations involving velocities and accelerations are derived. If we are given the desired instantaneous velocities and accelerations, the sought linkage is obtained by solving these three equations for the lengths and angles of the bars. Reference is made to S. Bloch [*Izv. Akad. Nauk SSSR*, 1940] for this method. M. Goldberg, USA

2237. Käppler, P., Determination of cam shape for force-closed cam mechanisms from the interaction between inertia and restoring force (in German), *ZVDI* **96,** 23, 782–788, Aug. 1954.

Describes a partly graphical procedure for designing cams, including a means for taking into account a variable follower mass. Procedure starts with a rectangular coordinate diagram of follower inertia force vs. follower displacement which is integrated to give follower kinetic energy versus displacement. From this can be calculated the follower velocity (taking into account variation of follower reduced mass). Time-displacement curve is then obtained by integrating $dt = ds/v$.

Author works four examples as applied to disk cams with roller followers and discusses the matter of designing for suitable limits on the transmission angle, selection of base circle radius, and selection of spring characteristic.

Author's procedure eliminates some of the trial and error in the more usual ways of arriving at a satisfactory cam design.

A. S. Hall, USA

2238. Ishihara, T., Studies of hydraulic torque converter [1st Report, (a) Method of calculating the characteristics of general type hydraulic drive, (b) Characteristics of single-stage torque converter for normal operation] (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 101, 61–67, 1955.

Applying Euler's theory to the flow in annular circuit and taking the shock and friction loss into consideration, the relation between the circulating velocity and the input and output torque of general type hydraulic drive has been deduced. In order to carry out the numerical calculation and to discuss the characteristics of the hydraulic torque converter of all types systematically, a procedure determining the reasonable arrangement of members in the circuit and the suitable shape of each vane has been derived as follows.

Assuming that the shape of each member or vane may be expressed by radii and blade angles at its entrance and exit, and that the flow at the entrance of each member may be shockless at the specific operating condition which is named "reference point," the energy equation, the shockless flow conditions, and the conditions of maximizing the efficiency at reference point are obtained. Accordingly, the characteristics may be calculated numerically and systematically by using the speed ratio and the circulating velocity at reference point as parameters.

By way of example, the quantitative tendency of characteristics of single-stage torque converter for normal operation has been made clear. From author's summary

2239. Ishihara, T., Studies of hydraulic torque converter [2nd Report, Characteristics of multistage torque converter for normal operation and of single-stage reversing torque converter] (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 101, 68–73, 1955.

It has been clarified that the calculating method described in the previous report is applicable to the cases of multistage torque converter and reversing one. Hence the numerical calculations have been carried out to make clear the quantitative tendencies of characteristics of two- and three-stage torque converter for normal operation, and to examine how the reversing torque converter may be put to practical use.

As a result, it has been concluded that: (1) Multistage torque converter may have higher stall torque ratio than single-stage without depressing maximum efficiency. (2) Maximum efficiency of single-stage reversing torque converter may reach about 70% or more, provided that the members are arranged in the order of pump→stator→turbine and the blade angles are suitable. From author's summary

2240. Ishihara, T., Studies of hydraulic torque converter [3rd Report, (a) Comparison between characteristics of *P-T-S* and *P-S-T* type, (b) Effects of width of flow path on characteristics] (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 101, 74–78, 1955.

As the results of numerical calculation and theoretical consideration, it is concluded that:

(a) Pump→turbine→stator type is suitable to normal operation use and pump→stator→turbine type to reverse operation, so far as only the single stage is concerned.

(b) In order to guarantee that the efficiency of the whole flow path is equivalent to the value calculated on the design path, it is desirable that the condition of flow at the trailing edge of each member satisfies equation $(rv_\theta)_0 = \text{const}$, where r is radius, v_θ is circumferential component of absolute velocity at any point of trailing edge, and suffix 0 represents the reference point.

From author's summary

2241. Hayashi, T., and Akasaka, T., On the tension-distribution in a roller chain, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 87–92.

Authors determine stresses in the pins and plates of the chain of a sprocket chain drive. Cases considered and main results are: (1) Static tension—chain tension is important only in the range of two or three pitch lengths; (2) running chain—in general the rotating effect can be neglected in comparison to the static case; (3) effects of eccentricity between outside and inside link plates are considered for various assumed platepin conditions—stress distributions were determined for the various cases and this effect may be of importance in some cases. S. F. Borg, USA

2242. Colombo, G., On the motion of two heavy rigid bodies connected at one point, one of the two bodies having a fixed point (in Italian), *R. C. Semin. mat. Univ. Padova* **12,** part II, 305–312, 1953.

Two rigid heavy asymmetric bodies S_1, S_2, forming system S, are studied; S_1 has a fixed point and S_2 can rotate around point Q fixed in S_1. ω_1 and ω_2 being the angular velocities of S_1 and S_2, the motions of S which correspond to uniform rotary motions of S_1 and S_2 are characterized.

It is proved that system S moves as a sole rigid body except for two exceptional cases. Applying Signorini's extensions to stereodynamics of the motions of central ellipse and the polarity subordinates to it, there results that the system S can move rigidly in uniform rotation around an axis that passes by O, if, and only if, certain stated conditions are complied with.

Then the following two questions are studied: (1) Does a straight line exist which complies with (1), (2), and (3) when O, Q and the mutual position of S_1 and S_2 is prefixed? (2) With O and Q prefixed, may S be directed with respect to S_1 so that such a straight line a exists?

Finally, (2) is answered affirmatively in the particular case where OQ is vertical; then a uniform rotary motion of S around it is possible. R. R. Hunziker, Argentina

2243. Kolchin, N. I., Curvature of conjugate surfaces in spatial gearings (in Russian), *Akad. Nauk SSSR Trudi Sem. Teoriĭ Mash. Mekh.* **13,** 49, 5–15, 1953.

The differential geometry of a pair of mating surfaces is illustrated by the example of a worm (whose thread section is the same as an involute gear tooth) driving a worm-wheel. The coefficients of the differential quadratic forms of the first and second orders are developed from the equations of the mating surfaces. The curvature of a normal section of a surface is then expressed in terms of these coefficients. In particular, for the contact point on the normal from the center of the wheel to the axis of the worm, the radius of curvature K of the wheel tooth, on the normal section parallel to the wheel axis, is $R \sin \delta$, where R is the pitch radius and δ is the pressure angle.

M. Goldberg, USA

2244. Bautin, N. N., A dynamic model of a watch movement without a characteristic period (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **16,** 3–12, 1953.

A standard simplified model of a clock with the pendulum replaced by a continuous band with stops. The period and amplitude of the oscillations are determined.

S. Lefschetz, USA

2245. Cherenin, V. P., Symbolic representation and the synthesis of regular toothed mechanisms consisting only of members with fixed axes of rotation (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 3, 24–38, 1954.

Several toothed circular gears are mounted on a fixed shaft and are meshed with another set mounted on another fixed shaft. Various transmission ratios are obtained by the various methods of connecting, through clutches, the gear pairs into a gear train. The systematic method of obtaining all the possible connections, and therefore all the possible transmission ratios, involves a study of all the connections similar to the possible graphs and trees. Tabulated schemes up to seven clutches are presented. An illustrated example using four gear pairs and five clutches gives six ratios; 26 arrangements give a set of ratios of the type *a, b, c, pa, pb, pc,* while 24 arrangements give a set of the type 1, *a, b, p, pa, pb.* M. Goldberg, USA

2246. Horan, R. P., Overhead valve gear problems, *SAE Trans.* **61,** 678–686, 1953.

2247. Barkan, P., Calculation of high-speed valve motion with a flexible overhead linkage, *SAE Trans.* **61,** 687–700, 1953.

2248. Roggenbuck, R. A., Designing the cam profile for low vibration at high speeds, *SAE Trans.* **61,** 701–705, 1953.

2249. Turkish, M. C., Relationship of valve-spring design to valve gear dynamics and hydraulic lifter pump-up, *SAE Trans.* **61,** 706–713, 1953.

2250. **Corbetta, G., The pneumatic shock-absorber unit of an aircraft landing gear** (in Italian), *Aerotecnica* **34**, 2, 86–91, Apr. 1954.

Servomechanisms, Governors, Gyroscopics

2251. **Weber, E., Linear transient analysis. Vol. I. Lumped-parameter two-terminal networks,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xiv + 348 pp. $7.50.

Author presents a semirigorous development of the most widely used mathematical tools for solving constant-coefficient, ordinary, linear differential equations. Each technique is developed from concepts based on classical techniques and the properties of exponential functions. Care is taken to emphasize points of similarity and dissimilarity among the various methods and to show how the methods are interrelated.

Chap. 1 develops the electric circuit concept from field and energy considerations and derives the general equations of electrical networks. An initial statement is needed concerning linearity of dielectrics and magnetic media, since some of the energy expressions would otherwise be invalid for nonlinear situations.

Chap. 2 presents classical methods of solving the differential equations, nature of ideal discontinuous sources, and the superposition theorem.

Chap. 3 discusses the analog method. In the electrical analog for mechanical systems, a different emphasis is needed. Author emphasizes direct analogs (force-to-voltage) which yield topological duals. The mobility analog (force-to-current) is more rapid in application since it preserves topological similarity. Some difficulties that are faced in the examples of electromechanical systems can be avoided by proper choice of analog.

Chap. 4 introduces the Heaviside-Jeffries operational calculus and develops the techniques from the integral operator which seems more "natural" and more significant.

Chap. 5 presents the Laplace transform and shows how this tool places the operational calculus on a rigorous basis. The transformation concept is emphasized and it is pointed out that the operational equations of Heaviside are really integral equations in the time domain, whereas transform equations of necessity are expressions in terms of a new variable.

Chap. 6 introduces the spectrum concept and develops Fourier series and integrals and the Fourier transform. The limitations of these tools are pointed out vis-a-vis the power of the Laplace transform.

Five appendixes cover notation, fields, factorization, matrixes, complex variables, and bibliography. L. A. Gould, USA

2252. **Tsien, H. S., Engineering cybernetics,** New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xii + 289 pp. $6.50.

The subject matter of this book is in a sense less general than the title suggests. Author does not cover the fields of communication and computing machines included by Professor Norbert Wiener in his concept of "Cybernetics." Professor Tsien restricts himself to the theory of control systems. He has selected a number of outstanding papers from the major areas of modern automatic control theory and incorporated them into a book.

After a discussion of Laplace transforms, transfer functions, and frequency response, the Nyquist, Bode, and Evans methods for feedback system design are covered, followed by the Boksenbom and Hood theory on noninteracting controls. The author continues with the work of MacColl on a-c servos, Stibitz-Shannon on servomechanisms, Kochenburger on relay servomechanisms, Bushaw on switching functions, Draper on optimalizing controls, Wiener on the filtering of noise, as well as Drenick and the author on perturbation design methods.

Other topics are also treated. Engineering applications are omitted since Professor Tsien feels that these belong to servomechanisms engineering.

The author has combined the material of his book into a well-organized unified whole. R. Oldenburger, USA

2253. **Aĭzerman, M. A., and Gantmakher, F. R., Conditions for the existence of a region of stability for a single-loop system of automatic control** (in Russian), *Prikl. Mat. Mekh.* **18**, 1, 103–122, Jan./Feb. 1954.

The linear system investigated consists of a finite number of blocks with the individual transfer functions being rational with the numerator and the denominator being quadratic factors. The characteristic equation of the system is set up, and the "normal type" of systems is singled out. This imposes certain sign restrictions on the coefficients of the quadratic factors. The author then establishes and proves six theorems which give criteria for existence of regions of stability for six classes of "normal type" systems. Finally, the theory is applied to a physical system which is modified by various local feedbacks. Thus the theory also may be applicable to multiple-loop systems depending on the characteristic equation. The paper concludes by formulating the general problem of existence of a region of stability for a linearized automatic control system of any type.

The reviewer believes that this work, which is a more general continuation of authors' earlier work, is of considerable theoretical interest and also of practical value.

H. Christensen, Norway

2254. **Fujino, T., The stability of periodic controls (1st report),** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 639–644.

Paper treats a method for determining the stability of periodic—sometimes called "sampling"—process control systems. Method employed is not new but, as author indicates, is that proposed by R. C. Oldenbourg. Stability is determined by analysis of the difference equations resulting. Subject is of engineering significance because of wide application of this general control method, particularly in combustion controllers.

Utility of paper is limited because of presentation style which provides extreme brevity at cost of necessary explanatory material. In particular, mathematical symbols introduced are not always defined. Major value of paper lies in series of charts which show stability boundaries for a number of operating conditions. These would ordinarily be of value to designers faced with similar problems; however, their utility is also limited because of incomplete labeling and because of detail lost during the publication process. R. Kochenburger, USA

2255. **Nakada, T., Ikebe, Y., and Yamada, T., Numerical analysis of transient phenomena,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 589–594.

The Laplace transform is used to calculate an operational function from experimental observation of a transient phenomenon. A newly devised Riemann-Stieltjes integraph facilitates the calculations. A method is derived for finding frequency response from the result of indicial response. Also, the approximate transient response of a linear system to a unit impulse is found from the frequency response. The results should be useful in the analysis of servomechanisms. E. G. Fischer, USA

2256. Nakada, T., and Ikebe, Y., High sensitive pneumatic servomotor, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 645–650.

Paper describes analysis of response of a pneumatic servomotor and subsequent experimental verification of the analytic results. Device considered in this paper is a two-stage servomotor which employs well-known mechanical techniques. Value of paper is not in device described but in analytic approach employed to predict its response characteristics.

Engineering significance of paper arises from the fact that analysis of such devices has always been considered difficult because of nonlinear pneumatic phenomena involved. This paper employs certain types of linearizing approximations to make an analysis feasible; this has been done before. However, this paper has the additional feature that conclusions are correlated with experimental studies of both the frequency and transient response. These studies show an agreement between analytic and observed results, which is remarkable in view of the many approximations necessary in the analysis.

R. Kochenburger, USA

2257. Portnov-Sokolov, Yu. P., On the motion of a hydraulic piston control under typical loads, Collection of work on automatics and telemechanics by the Inst. of Automatics and Telemechanics; Akad. Nauk SSSR, 18–29, 1953. (Translation by M. D. Friedman, 2 Pine St., W. Concord, Mass.)

Paper presents the results of a study made by a group of young Russian specialists of the Institute of Automatics and Telemechanics of the action of a hydraulic piston motor controlled by a spool valve.

A second-order nonlinear differential equation is derived for the motion of the piston. The effects of piston and liquid inertias, of dry and fluid friction, and of various types of piston load are included in the equation. The equation is studied by the phase-plane method. An expression for maximum velocity and graphs of useful power against piston path are obtained. Finally, idealized systems are considered and expressions derived for (a) optimum value of piston area, (b) time of piston travel, (c) maximum velocity of piston.

The paper is relatively easy to follow and the mathematics is not difficult. Reviewer feels this paper to be a useful contribution to the field of hydraulic-control literature.

W. A. Wolfe, Canada

2258. Nightingale, J. A., How to fit power boosters into aircraft controls, *Control Engng.* **1,** 4, 24–28, Dec. 1954.

An account of the influence of control-surface actuators on the open-loop dynamics of an aircraft as felt by the pilot. Frequency-response method is used; results stated are elementary and well known. Poor typography; e.g., Figs. 3 and 5 should be interchanged to match text. R. E. Kalman, USA

2259. Caldwell, W. I., Round-Up: 12 ways of generating control functions pneumatically, *Control Engng.* **1,** 1, 58–63, Sept. 1954.

2260. Van Den Broek, J. A., Isochronal spiral regulator, *Amer. J. Phys.* **23,** 4, 224–239, Apr. 1955.

2261. Boksenbom, A. S., and Hood, R., Automatic control systems satisfying certain general criteria on transient behavior, *SAE Trans.* **61,** 594–607, 1953.

See AMR **5,** Rev. 2275.

Vibrations, Balancing

(See also Revs. 2233, 2250, 2446, 2471, 2482, 2566)

2262. Herrmann, G., Forced motions of Timoshenko beams, *J. appl. Mech.* **22,** 1, 53–56, Mar. 1955.

Proceeding along classical lines, the general solution is deduced for the forced flexural motions in a uniform beam predicted by the Timoshenko theory. The most general boundary conditions, initial conditions, and forcing functions are considered. The solution is given in the form of a superposition of the principal modes of vibration, modified slightly by the method of Mindlin and Goodman to account for time-dependent boundary conditions. R. A. Anderson, USA

2263. Dolph, C. L., On the Timoshenko theory of transverse beam vibrations, *Quart. appl. Math.* **12,** 2, 175–187, July 1954.

Starting from the equations, derived by Timoshenko, for the transverse vibrations of a beam which include the effect of transverse shear deformation, author discusses separation of variables and orthogonality relations. He gives a detailed account of the initial value problem and the normal modes of the uniform hinged-hinged beam as well as of beam problems involving external forces and moments and beam vibrations with time-dependent boundary conditions. E. Saibel, USA

2264. Troesch, A., Anliker, M., and Ziegler, H., Lateral vibrations of twisted rods, *Quart. appl. Math.* **12,** 2, 163–173, July 1954.

Differential equations of motion of a bar which, in its unstressed state, is twisted like a propeller blade are solved for the case of inertia loading. Natural frequencies of small vibration are computed and tabulated, for the case in which one of the flexural rigidities is very large compared with the other, for the first four modes of vibration of a fixed-free blade. Approximate expressions are obtained for the cases in which the total twist is very large or very small; intermediate values of critical frequency have been obtained by use of high-speed digital computer.

Reviewer feels that this work will find application in turbine and compressor blade design as well as in connection with propellers and that it represents a most useful application of modern high-speed digital computers. L. E. Goodman, USA

2265. Uematu, T., and Hamada, M., Approximate method by generalized coordinates in the problem of beam with stepwise varying cross section, *Technol. Rep. Osaka Univ.* **4,** 45–53, Mar. 1954.

The problem of forced vibration of a beam, which has stepwise varying cross section and is supported at both ends, is treated in this paper by making use of generalized coordinates.

Expressing the displacement of the beam as

$$y = \sum_{s=1}^{\infty} q_s(t) \sin (s\pi/l)x$$

kinetic and potential energies are calculated. Thereby the orthogonality is assumed approximately to simplify the solution, and the error of this approximate method is proved to be small enough as far as variations of section remain small.

From authors' summary by R. E. Heninger, USA

2266. Uematu, T., and Morikawa, Y., Approximate method by generalized coordinates in the problem of circular plate of stepwise varying thickness, *Technol. Rep. Osaka Univ.* **4,** 55–63, Mar. 1954.

In this paper, an approximate method is given for the forced

vibration and the statical deflection of a circular plate, of which the section is not uniform but varies stepwise.

The characteristic of this approximate method lies both in neglecting the term for small thickness variation in calculating the kinetic and potential energy that vanishes in the case of uniform thickness by virtue of the orthogonality of function, and in assuming the continuity of deflection, slope, bending moment, and shearing force at the i-th joint of thickness in calculating the exact solution of statical deflection.

According to the numerical solution of the statical deflection, the approximate method is proved to give satisfactory accuracy.

From authors' summary by R. E. Heninger, USA

2267. **Tumura, T., and Ōba, Z., Circumferential vibration of a turbine disk,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 557–559.

Failures in fatigue due to vibration are occasionally encountered in short turbine buckets which have a high first fundamental frequency. The frequency necessary to excite the critical may be outside the range of those computed as probable sources of excitation, by the usual methods. The present authors have found that the disk frequency in a circumferential direction may be a source of excitation for bucket vibration in a transverse direction. Calculations were made for a thin disk the circumferential natural frequencies of which varied from 2300 cps to 11,000 cps. The conclusion is that the circumferential natural frequencies of the disk should be taken into account as a source of exciting frequency of the blades in turbine design. E. G. Allen, USA

2268. **Deresiewicz, H., and Mindlin, R. D., Axially symmetric flexural vibrations of a circular disk,** *J. appl. Mech.* **22,** 1, 86–88, Mar. 1955.

Paper contains a discussion of the axially symmetric flexural vibrations of a free disk with emphasis on behavior in the neighborhood of the thickness-shear frequency.

The equations of motion for this case are derived and the frequency spectra are drawn, both for the theory given in the paper and for the classical theory. These spectra are compared and it is pointed out that the discrepancy increases with the ratio of plate thickness to wave length of the mode, and hence with the order of the mode. The most striking difference between the two theories occurs at frequencies above that of the fundamental thickness-shear mode. N. O. Myklestad, USA

2269. **Maier, K. W., Dynamic loading of compression springs,** *Prod. Engng.* **25,** 1, 162–167, Jan. 1954.

Paper discusses wave propagation in closely coiled, helical wire springs on the basis of usual wave equation. Correction attempting to take into account rotational inertia appears to be in error as it assumes rotation of cross section about axis of wire to be directly proportional to displacement along axis of coil.

G. W. Housner, USA

2270. **Maier, K. W., Dynamic loading of compression springs,** *Prod. Engng.* **26,** 3, 162–174, Mar. 1955.

Further discussion of wave propagation in springs. Author presents some interesting experimental photographic records of time-displacement history of each coil of a spring when subjected to rapid loadings. Experimental results are in good agreement with elementary theory. G. W. Housner, USA

2271. **Gillies, A. W., On the transformations of singularities and limit cycles of the variational equations of van der Pol,** *Quart. J. Mech. appl. Math.* **7,** part 2, 152–167, June 1954.

The question is to study the regime of a nonlinear oscillator of the second order, receiving a wave of fixed frequency and amplitude. Van der Pol has given the variational equations of the system and solutions of these in two limiting cases. The middle region has been discussed with increasing precision by Andronow and by Cartwright. Author rectifies a mistake made by Cartwright.

An interesting paper which illustrates the difficulty of following the changes in the topology of a family of curves depending upon two parameters. P. Le Corbeiller, USA

2272. **Biryuk, G. I., On the existence of almost periodic solutions of nonlinear systems with a small parameter in the case of degeneration** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **97,** 577–579, 1954.

Author considers the problem of determining the almost-periodic solution of the nonlinear system

$$dx/dt = Ax + \epsilon f(x, t)$$

in the case where $f(x, t)$ is an almost-periodic solution of t uniformly in x and where A possesses characteristic roots with zero real part. Under certain assumptions, he is able to show that the formal solution, obtained as a power series in ϵ, is an actual solution. R. Bellman, USA

2273. **Hukuo, N., Transient oscillations of nonlinear systems,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 611–614.

Transient solution is obtained for equation of motion of the type $\ddot{x} + f(x, \dot{x}) + g(x) = p(\omega t)$ in which (ωt) is a square wave function. Transient diagrams are obtained for two applications of Duffing's equation. P. G. Jones, USA

2274. **Nishino, K., and Watanabe, G., On the resonance of the oscillatory system with a small clearance,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 615–620.

An analytical investigation is made on the effect of a small clearance on the amplitude at resonance, the peak amplitude, and the peak frequency for harmonic excitation. Results were found to be in fair agreement with results of an experimental study presented in paper. Excitation was obtained by magnetic oscillator and damping was obtained by use of a pair of plates immersed in an oil vessel. P. G. Jones, USA

2275. **Shimizu, T., On differential equations for oscillations with after effect and nonlinearity,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 305–306.

If Φ is the magnetic flux, i the current in an electrical circuit with iron core, author writes and discusses the relation

$$i = c\Phi + d\Phi^3 - \int_{-\infty}^{t} f \exp[-\psi(t - \tau)]x(\tau)d\tau \qquad [1]$$

which takes into account nonlinearity and aftereffect; [1] is also suitable for some elastic material. Author writes also the differential equation for forced oscillations in the circuit and tries to solve it by a method similar to the approximate methods of nonlinear mechanics. D. Graffi, Italy

2276. **Walsh, J. P., and Blake, R. E., Evaluating shop mounts,** *Mech. Engng., N. Y.* **77,** 3, 231–235, Mar. 1955.

2277. **Bauer, F., Movements of an elastically supported mass with excitations coming from the supporting side** (in German), *Bauingenieur* **29,** 3, 99–102, Mar. 1954.

The equations for the movements of the mass are derived in the classical manner for the cases of vertical and horizontal

excitation in the planes of support and rotation around a horizontal and a vertical axis in and perpendicular to this plane. The suspension is treated as a perfectly elastic body and the damping is taken proportional to the velocity of the movement of the mass. R. H. Boiten, Holland

2278. Nicolaisen, J., Reduction of shipboard vibration by rubber units, *European Shipbldg.* **5,** 3, 124–131, 1954.

2279. Brosinsky, H.-J., Vibrations of the control mechanism of a valve system (in German), *Motortech. Z.* **15,** 9, 255–271, Sept. 1954.

Author describes an experimental investigation on the effect of valve-gear elasticity on valve motion and also attempts to explain the results analytically.

Two effective experimental methods have been developed: (a) The valve motion causes a change of induction, which is then photographically recorded by means of an oscillograph; (b) valve spring vibrations are photographically recorded on a strip film, using just one brilliantly lighted point on every spring turn.

The main results of the valve-motion measurements shows that, at normal motor speed, the valves rebound once or twice after closing. Author believes this rebound is caused by elastic shock between valve and seat, sometimes with an interfering valve-gear vibration. He supports this idea by some simplified, approximate calculations, which take into account the mass and elasticity of the valve, valve gear, and valve seat. Good agreement between the calculated and measured rebound heights is obtained.

The principal result of the valve spring measurements is that vibrations are excited not only by the several harmonic components of the theoretical (no elasticity in the valve gear) motion corresponding to the cam contour, but also by shocks either in the valves after closing or in the valve gear after opening. When the closing and opening shocks are in phase, strong spring vibrations may be produced through resonance.

Author tested several valve springs and found that additional shearing stresses due to spring vibrations are smaller in stiffer, and larger in softer springs. The total shearing stress oscillation amplitude (static stress due to valve lift, plus dynamic stress due to vibration) was found to be approximately the same in all tested springs.

Author suggests that, in order to prevent unfavorable effects, the mass and elasticity of valve gears should be reduced as much as possible. R. Giovannozzi, Italy

2280. Larsen, H. W., Vehicle vibration and stress testing, *Proc. Soc. exp. Stress Anal.* **12,** 1, 125–134, 1954.

The usual vehicle vibration problem cannot be approached analytically and thus experimental methods must be employed. These involve the use of many reliable transducers and indicating or recording instruments. This paper discusses some of the techniques employed in this work and describes a few typical test setups. From author's summary

2281. Long, R. H., Jr., Experimental and theoretical study of transverse vibration of a tube containing flowing fluid, *J. appl. Mech.* **22,** 1, 65–68, Mar. 1955.

Free transverse vibrations for the fundamental mode of a single-span tube containing flowing fluid are investigated analytically and experimentally. An appropriate solution of the differential equation of motion is made with a power series. Proper computational technique for evaluating solution is described. For simply supported span, solution indicates small decrease in frequency and no decay of vibrations. For fixed-free ends, solution indicates decaying vibrations and slight frequency decrease. Experimental results are consistent with solution.

G. W. Housner, USA

Wave Motion in Solids, Impact

(See also Revs. 2269, 2270)

2282. Rinehart, J. S., and Pearson, J., Behavior of metals under impulsive loads, Cleveland, Ohio, American Society for Metals, 1954, 256 pp.

Book reviews the concepts and experiences that have become associated with the field of impulsive loading. The character of impulsive loading is discussed; the necessary conditions of developing this loading are indicated together with the main phenomena which result when material, particularly metals, and systems of material bodies are subjected to these rapidly applied loads of short duration; and the techniques and apparatus useful in experimental investigations are described.

The approach in most cases is broad and general in order to delineate concepts and main aspects of the field. This will disappoint an expert in the field but the contents may broaden his viewpoint. Others will become aware of the nature of impulsive loading phenomena. They will see the engineering utility of the concepts and experiences presented which, if heeded, will lessen the chances of failure in structures subjected to impulsive loads, and they will acquire a background which will aid in developing new concepts and test methods in this field.

Since materials are likely to react differently under impulsive loads than under conventional loading, facts related to the static behavior which are useful in determining the dynamic behavior are pointed out together with any relationship which may exist.

The manner of presentation by the authors follows a definite pattern. Each chapter begins with an introduction which describes the subjects and experiences to be covered in the body which follows. The chapter is closed with a summary of the pertinent information. This results in a slight duplication of part of the introduction but will aid those who use the book as a reference. M. J. Manjoine, USA

2283. Boley, B. A., An approximate theory of lateral impact on beams, *J. appl. Mech.* **22,** 1, 69–76, Mar. 1955.

Paper presents a theory that takes into account the lateral contraction of a beam in addition to the well-known considerations of shear deformation and rotary inertia due to Timoshenko. The author is primarily concerned with an approximate method of solution, for the governing equation and boundary conditions, based on assumed displacement expressions. The method stems from a detailed examination of the terms of this equation, made with the aid of order of magnitude comparisons, to determine their importance for particular regions of time. On the basis of time comparisons with a critical quantity, it is concluded that, for small times, the shear and rotatory inertia terms are more important than the bending terms, whereas for large times the bending terms would suffice (hence, the applicability of the Bernoulli-Euler equation). For intermediate times all terms are required.

The method of solution is good for the early times; specifically, it applies to a short region of the beam just behind the initial disturbance, hence, a region in which the shear and rotatory inertia effects are important. Four numerical examples are given and comparisons are made with solutions from the Bernoulli-Euler and Timoshenko bending theories. In one of these examples, the Timoshenko theory solution and the approximate solution show good agreement (within the appropriate time) for the

shear force variation at the impacted end of the beam. Paper contains several new points of interest on this subject.
J. Miklowitz, USA

2284. **Kawashima, S., The dynamic bending of elastic bars due to longitudinal impact,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 583–587.

Author considers a slightly curved bar subjected to a suddenly applied circumferential velocity at one end and proposes to determine the ensuing history of deflection and bending moment. Both circumferential and radial inertia forces are considered, but in contrast to the usual static analysis of columns, the effects of displacement on the equilibrium conditions are neglected; consequently, the analysis is explicitly restricted to a short time interval after the initial impact. Both a semi-infinite hinged beam and a finite hinged beam are considered, and results are found approximately by operational methods. Calculated results indicate a concentration of bending moment near the struck end in the case of the semi-infinite beam, and near both ends in the case of the finite beam. B. Budiansky, USA

2285. **Housner, G. W., Hudson, D. E., and Alford, J. L., Ground shock and building motions produced by a quarry blast,** *Proc. Soc. exp. Stress Anal.* **11, 2,** 133–138, 1954.

Results of measurements of ground and building accelerations at a point 400 yards from a charge of 370,000 lb of nitramon explosive are given. Maximum horizontal acceleration of the ground was 0.13 g, and the horizontal acceleration in the building in the direction measured was 0.11 g. Instruments used are described, and a comparison of ground motions with those occurring during earthquakes is made. From authors' summary

Elasticity Theory

(See also Revs. 2283, 2298, 2304, 2305, 2309, 2312, 2322, 2371, 2490)

2286. **Nowiński, J., and Olszak, W., On the bases of the theory of physically nonlinear elastic bodies,** *Bull. Acad. Polonaise Sci.* **2,** 3, 107–111, 1954.

Discussion of certain problems is based upon an incorrect correlation of elastic-plastic with nonlinear elastic mechanical behavior. Paper is brief, and reviewer does not follow the arguments. H. G. Hopkins, England

2287. **Gross, W. A., and Soroka, W. W., Network representation of elastic problems in cylindrical coordinates,** *Proc. Soc. exp. Stress Anal.* **11, 2,** 45–58, 1954.

Applications of Kron's analogy between elastic fields and electric circuits are extended to problems in cylindrical coordinates. The authors make it clear that the circuit finds its practical use as a guide for numerical solutions rather than as a piece of physical equipment. Results of computations are given for solid and hollow rotating shafts. R. D. Mindlin, USA

2288. **Yoshimura, Y., On the natural shearing strain,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 1–4.

In the case of pure shear, author develops formulas for shear strain and extensional strain at finite deformations. Deductions are both geometrical and analytical. As an example, the finite torsion of thin circular tubes assuming plane strain is treated. Author shows that neither the diameter nor the length of the tubes is changed. Å. Isaksson, Sweden

2289. **Nakazawa, H., Torsion of the angle,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 105–108.

Torsion problem for angle sections is solved using an approximate conformal transformation. Numerical results are given for maximum shear stresses and torsional rigidity.
W. S. Hemp, England

2290. **Nagai, T., Numerical method of determining two-dimensional stress,** *Bull. Fac. Engng., Yokohama Nat. Univ.* **2,** 47–61, Mar. 1953.

A deep beam of finite length and with a protrusion on one side is solved numerically as a circumscribed rectangular beam minus the superfluous portion. The rectangular beam is solved in Fourier series with the two end boundary conditions satisfied by the method of least work, following the procedure used by Conway, Chow [AMR 5, Revs. 1029, 3056]. Stresses in the superfluous portion are computed by conformal transformation and successive approximation and then subtracted from the rectangular beam stresses. A numerical example is given.
M.-L. Pei, USA

2291. **Cowan, H. J., and Armstrong, S., The deformation of concrete in compression and torsion,** *Civ. Engng., Lond.* **49,** 580, 1080–1081, Oct. 1954.

Results obtained from the control tests of a major investigation on the stress distribution in reinforced and prestressed concrete are presented. From authors' summary

2292. **Pestel, E., A new flow analogy for torsion** (in German), *ZAMM* **34,** 8/9, p. 322, Aug./Sept. 1954.

2293. **Nowiński, J., The torsion of a thin-walled conical tube with a longitudinal slot,** *Bull. Acad. Polonaise Sci.* **2,** 2, 63–67, 1954.

A thin-walled, straight conical tube, fixed at the larger end in a rigid foundation, is submitted to torsion. The tube has no internal walls and a longitudinal cut, bounded by two generators. Considering rotation and warping, author deduces the equations for the normal and shear stresses. He then computes the action of two couples M_z obtaining, with several simplifications, formulas of practical use for these stresses. H. Beer, Austria

2294. **Das, S. C., On the concentration of stresses due to a small elliptic inclusion on the neutral axis of a deep beam under constant bending moment,** *ZAMP* **5,** 5, 389–398, 1954.

Problem of title is discussed as a two-dimensional problem in curvilinear coordinates. Stresses are worked out in detail for three ratios of Young's moduli of the two materials.
H. D. Conway, USA

2295. **Sonntag, G., Compensation of cutout boundary loads of an elliptically cutout shell through loading the shell without cutout** (in German), *ZAMM* **34,** 8/9, 330–331, Aug./Sept. 1954.

Experimental Stress Analysis

(See also Revs. 2280, 2287, 2380)

2296. **Kodama, M., and Nakahara, I., Stress analysis of the coiled spring by use of brittle coatings,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 171–174.

Starting with the stress distribution in a coiled spring, according to the calculations of Wahl and Göhner. the expressions for

the shearing stresses τ_i and τ_o and the bending stresses σ_i and σ_o at the inner and outer side of the coil are expanded for the case when the applied load on the spring acts eccentrically. As the angle between the direction of the principal stress and the axis of the coil wire is a function of the ratio between σ and τ, this ratio could be determined with a number of springs by measuring the afore-mentioned angle from a brittle lacquer crack pattern. For most of the springs, the agreement between the calculated and the measured value of this angle was well within 10%.

By measuring the angle of the cracks in eight points at equal distances around the coil and making use of the derived equations for σ_o and τ_o, the eccentricity of the actual load could be determined. From the results it follows that the stress distribution varies around the coil and that the usual calculation formulas for a coiled spring presents the mean value of the stresses.

R. G. Boiten, Holland

2297. Nakahara, I., Tumura, T., and Shibuya, T., Brittle coatings for the stress measurements, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for theor. appl. Mech., May 1953, 165–170.

A brittle lacquer is described, composed of limed rosin, a plasticizer (dibutyl-phthalate), and dissolved in a mixture of toluol and xylol. The coating is sprayed on the surface of the test object and must be dried 1–3 hours at a temperature of 50–60 C. The first crack appears with a uniaxial strain about $700 \cdot 10^{-6}$. The distance between the cracks on a bending bar proved to be roughly proportional to the strain.

The directions of the cracks agree with the lines of principal stress, although with a bending-bar test the neutral axis did not correspond with the middle line of the bar, but was shifted somewhat to the side of the compressive stresses. This phenomenon is not further investigated. R. G. Boiten, Holland

2298. Edamoto, I., An electrical method for solving the torsion problem of a cylindrical body, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 215–218.

A direct-current and alternating-current analógy are established for solving Poisson's equation in two dimensions. In the d-c system, an electrolytic tank is used. Bottom of the tank consists of a layer of semiconducting material in contact with electrolyte. Lower surface is maintained at a high potential through contact with a metal plate. A-c system is similar in form with a dielectric substituted for semiconductor. Boundary conditions corresponding to torsion problems of bars with either singly or multiply connected cross sections are readily simulated. A direct method for evaluating twisting moment is described for a-c analogy.

Reviewer notes that erroneous omission of a constant factor from equations for moment makes proposed direct measuring scheme appear more attractive than warranted.

Author states experiments are in progress with the a-c method. No quantitative results are given. R. E. Newton, USA

2299. Walton, J. D., Jr., Apparatus for automatically recording strains between enamel and metal, *J. Amer. ceram. Soc.* **38,** 3, 114–118, Mar. 1955.

The construction and operation of a mechanism for converting the movement of an enameled split ring into a suitable electrical signal to be automatically recorded are described. Strain curves are presented for a single enamel when applied to several metals. These data were used to determine the relationship between the strains recorded and the properties of the metals to which the enamel was applied. From author's summary

2300. Faure, G., Effect of temperature on the stability of electric strain gages fixed with thermoplastics (in French), *Rech. aéro.* no. 40, 33–36, July/Aug. 1954.

2301. Svensson, N. L., A new electric resistance strain gage for large strain, *Proc. Soc. exp. Stress Anal.* **11,** 1, 197–202, 1953.

In the formulation of stress-strain laws for work-hardening metals in the plastic range, attention must be paid to the accurate measurement of strain. Electric resistance strain gages are very convenient to use, but, unfortunately, are not generally available to measure high strains. This note deals with the development of a new type of unbonded electric resistance strain gage which can be designed to measure strains up to 8 or 10%, and yet be in a position to measure the elastic strains resulting from unloading the specimen. The form of a suitable gage has been developed and sufficient information presented to enable the performance of a particular gage to be estimated.

From author's summary

Rods, Beams, Cables, Machine Elements

(See also Revs. 2241, 2262, 2263, 2264, 2265, 2281, 2283, 2284, 2289, 2290, 2294, 2296, 2329, 2350, 2362, 2365, 2366, 2376)

2302. Kacner, A., and Lewicki, B., Nonuniformly heated beams on elastic foundation (in Polish), *Inżyn. Budown.* **11,** 4, 122–128, Apr. 1954.

A few special problems of beams on elastic foundations (simply supported at some points or without supports) and with nonuniform temperature distribution through the thickness of the beams, assumed to be linear, have been solved. Numerical illustrative examples supplement theoretical solutions.

R. M. Evan-Iwanowski, USA

2303. Christodoulides, S. P., A two-dimensional investigation of the end anchorages of post-tensioned concrete beams, *Struct. Engr.* **33,** 4, 120–133, Apr. 1955.

2304. Nowiński, J., The torsion of a rectangular bar with one cross section remaining plane, *Bull. Acad. Polonaise Sci.* 2, **2,** 57–61, 1954.

Author deals with the general case of torsion in a rectangular shaped bar, whose ratio of sides $\kappa = a/b$ can take any value. Starting from the solution proposed by L. S. Leibenson for the function of torsion, $\varphi = Axy + Cxy^3 + Dx^3y$, he expresses the warping for a bar encastré on its one end, $w(x, y) = \Theta\varphi(1 - e^{-\gamma z})$. Normal and shear stresses then can be obtained easily. The parameter γ is determined by means of the principle of Castigliano. Finally, a diagram of γ in function to the ratio of sides κ is presented.

Author concludes that order of magnitude of normal stresses for a rectangle 1:2 corresponds to that of maximum shear stress, determined by the theory of Saint Venant.

H. Beer, Austria

2305. Ling, C.-B., and Lee, T.-C., Stress systems in an infinite cylinder, *Ann. Acad. Sinica, Taipei* **1,** 517–526, 1954.

Paper contains particular solutions of the field equations in the classical theory of elasticity, appropriate to the problem of torsionless axisymmetry for a circular cylinder of infinite length. The solutions are generated by means of Love's stress function and are in Fourier integral form. The problems presented by a cylinder subjected to a circumferential normal or tangential line

load are considered in detail. No reference is made to the extensive previous literature on this subject [see, e.g., I. N. Sneddon, "Fourier transforms," McGraw-Hill, New York, 1951; AMR 4, Rev. 3753]. E. Sternberg, USA

2306. **Sherman, D. I., Transverse bending of an elliptic beam weakened by a longitudinal cylindrical hole** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17,** 121–150, 1953.

Analysis of cantilever beam of elliptical cross section, with longitudinal circular-cylindrical hole concentric with ellipse, loaded at free end by transverse force in direction of major axis of ellipse. Numerical results are presented in somewhat implicit form for a limited variety of ratios of cross-sectional dimensions, and some of them are compared with elementary solution. Reading of this 30-page paper, as with many other recent Russian articles, is seriously hampered by presence of only one single figure, bibliography consisting of a single item, absence of a list of symbols, and general lack of organization of material.

G. Winter, USA

2307. **Owada, S., Calculation of tensile and torsional stiffnesses of single-lay cables,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 159–164.

Author applies Kirchhoff's thin rod theory to obtain effect of contact pressure on stiffness of cables in a core-side wire cable combination under tension and torsion. Author obtains expressions for these stiffnesses and points out that they agree well with results of experiments. S. F. Borg, USA

2308. **Yoshida, S., On the moments applied to wires during the stranding process,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 109–112.

It is found experimentally that a stranded wire is twisted more easily than an unrestricted wire and that its torsional stress-strain characteristic is affected by the existence of stress resulting from the inevitable bending moments and torsional moments which are applied to it during the stranding process.

In this report, the stress produced by combined bending and twisting, and the moments applied to a wire during this process, are calculated theoretically. From author's summary

2309. **Abramyan, B. L., On the problem of torsion of nonhomogeneous prismatic bars** (in Russian, with Armenian summary), *Akad. Nauk Armyan. SSR Dokladi* **14,** 9–14, 1951.

An approximate solution, based on the theorem of minimum potential energy, is outlined for the Saint Venant torsion problem for beams with multiply connected cross sections. It is supposed that the elastic medium is reinforced along the contours of the cross section by thin layers of material with high shearing modulus. An example is worked out for the special case of the hollow circular pipe, but no attempt is made to estimate the accuracy of approximations. I. S. Sokolnikoff, USA

2310. **Thomas, A. K., Strength of gears [Die Tragfähigkeit der Zahnräder], 2nd ed.,** München, Carl Hanser Verlag, 1954, 182 pp., 88 figs., 35 tables. DM 14.80.

Author expounds the geometrical solution in the problem of calculating the dimensions of gears and the wheel and gives elements of construction. In the study of the dynamic problem the relations are given between the external forces and the tensions which arise at the contact of gears. Also the problem of the influence of friction on the high-speed revolving wheels is examined, using Hofer's formulas, etc. In chaps. B and C, the conical spur wheels are examined in the case of straight and curved sections and also the transmission of high capacity through a system of a worm gear.

The book contains 35 arithmetical tables and many diagrams and quite a large number of arithmetical applications. Thus the reader becomes versed in the calculation of gear systems. There is a detailed bibliography at the end. The book is useful for students and designers and gives interesting information to those who are occupied with matters of spur wheels.

C. Papaioannou, Greece

2311. **Fiala, T., A number of gears in common mesh** (in German), *Werkstatt u. Betrieb* **87,** 10, 618–622, Oct. 1954.

Paper gives the necessary relation between number of teeth and relative position of gear centers (i.e., angles of polygon formed by gear centers) in order to bring a number of teeth into common mesh. S. Sjöström, Sweden

2312. **Budinsky, F., and Světnička, F., Calculation of yield point of machine elements subject to alternating stresses** (in German), *Maschinenbau-Technik* **3,** 7, 353–360, July 1954.

2313. **Crossland, B., Thread inserts,** *Engineer, Lond.* **198,** 5157, 726–727, Nov. 1954.

Some pull tests on thread inserts in two light alloys, carried out at the University of Bristol, are here recorded. Incidentally, the tests revealed that the conventional depth of insertion of mild steel studs is unnecessarily large. From author's summary

Plates, Disks, Shells, Membranes

(See also Revs. 2266, 2268, 2290, 2293, 2295, 2326, 2328, 2330, 2348, 2363, 2365, 2374, 2381)

2314. **Woinowsky-Krieger, S., Clamped semicircular plate under uniform bending load (Brief Note),** *J. appl. Mech.* **22,** 1, p. 129, Mar. 1955.

By the use of bipolar coordinates instead of the usual polar coordinates, author obtains an exact solution. Comparison is made with previous approximate solutions. A printing error is noted. The transformation should be $x + iy = a \tanh 1/2\,(u + iv)$.

G. Pickett, India

2315. **Naghdi, P. M., The effect of elliptic holes on the bending of thick plates,** *J. appl. Mech.* **22,** 1, 89–94, Mar. 1955.

Reissner's theory for bending of elastic plates has been applied to obtain the effects of an elliptic hole in the case of plain bending and pure twist. The solution involving modified Mathieu functions is approximate in character. Stress-concentration factors have been considered for both cases. S. C. Das, India

2316. **Blokh, V. I., On the general theory of thick elastic plates** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **18,** 61–82, 1954.

Paper concerns a plate whose faces are loaded by normal or tangential forces which satisfy a polyharmonic equation. The method is to assume a displacement vector of the form

$$\mathbf{u} = w\mathbf{k} - z\nabla w + \sum_{n=1}^{m} [\varphi_n \Delta^n w\mathbf{k} + \psi_n \nabla \Delta^n w]$$

where ∇ is the Hamiltonian vector operator, Δ the Laplacian, the z-axis perpendicular to the plate, and ϕ_n, ψ_n are functions of z only. Polynomial expressions are obtained for the ϕ and ψ for various loadings of the faces. The coefficients in these poly-

nomials are then available for adjustment to edge conditions. They are determined explicitly for several problems concerning the circular washer. L. M. Milne-Thomson, England

2317. Ornstein, W., Note on rectangular plates: Deflection under pyramidal load, *Quart. appl. Math.* **11,** 3, 339–341, Oct. 1953.

Using standard method, this note gives the deflection of plate as a rapidly converging double sine series.

D. M. A. Leggett, England

2318. Frandsen, P. M., Difference methods on plates (in Danish), *Bygnstat. Medd.* **24,** 3, 77–132, 1953.

This paper is a direct continuation of two earlier publications by the same author ["Design of plates by means of difference equations" (in Danish), title source **1, 3,** 1929; and "On plates" (in Danish), title source, **XXIV**, 1, 1953], in which he introduced the terms "scalar moment"

$$U = (m_{xx} + m_{yy})/(1 + \nu)$$

as well as "vector moments" $V_{xy} = (m_{xx} - m_{yy})/(1 - \nu)$ and $W_{xy} = 2m_{xy}/(1 - \nu)$, and in which he developed the differential equations and the boundary conditions of these moments. In the present paper he demonstrates the practical application of these moments to circular, rectangular, and triangular plates by using Green's equation and various methods of differences.

Two types of Green functions are dealt with; viz., G-functions corresponding to point loads and F-functions corresponding to linear loads. Both are represented by the membrane surfaces pertaining to the afore-mentioned unit loads, these membranes being bounded by "reaction curves" of various types which are placed within, outside, or so as to coincide with the edge of slab.

For rectangular slabs, the analogy with beam formulas is shown. For polygonal slabs, author uses membrane surfaces in connection with the bounding surfaces of edge moments to demonstrate methods which correspond to funicular curves and closing lines, as in the case of beams.

The methods are illustrated by numerous examples.

S. T. A. Ödman, Sweden

2319. Radenković, D., Bending of an infinitely long plate supported by columns, *Bull. Acad. Serbe Sci.* **9,** 3, 7–9, 1952.

2320. Kaczkowski, Z., Certain closed forms of bending functions of a plate strip (in German), *Bull. Acad. Polonaise Sci.* **2,** 2, 75–77, 1954.

Using Green's function for an infinite rectangular strip which assumes zero value on the edges of the strip, author obtains expressions for the deflections of infinite rectangular strips under several types of loading in forms of definite integrals.

T. C. Lin, USA

2321. Hoff, N. J., Boundary-value problems of the thin walled circular cylinder, *J. appl. Mech.* **21,** 4, 343–350, Dec. 1954.

In a previous paper [AMR **7,** Rev. 1748] author and his associates have given a closed form solution of the homogeneous Donnell equations by using eigenfunctions with trigonometric expressions in the longitudinal direction. In this paper, author integrates the same set of equations by using eigenfunctions with trigonometric expressions in the circumferential direction. Expressions are obtained in explicit form for the displacements, membrane stresses, moments, and shear forces of a complete cylindrical shell of finite length. These results can be used in solving problems involving prescribed boundary conditions along circular boundaries, such as line loads and concentrated loads.

G. C. K. Yeh, USA

2322. Karlsson, K. I., Simple calculation of deformation and stress in the shell of thin-walled cylindrical vessels, *Proc. roy. Swed. Acad. Engng. Sci.* no. 213, 24 pp., 1954.

Author recognizes that the problem of the design of rotary kilns is similar to that of pipelines for power plants. Approximate expressions are developed for the stresses and deformation of the shell of a rotary kiln and the distribution of the reaction in the bearing ring. The stiffening effects of the liner are considered.

Marshall Holt, USA

2323. Nakahara, I., On the deformations of the Bourdon tube, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 31–36.

Author studies the deformations of a Bourdon tube the cross section of which is formed with two semicircles and two straight lines. In order to confirm the theoretical results, the angular displacement of the center line of the curved tube was measured. The results are in much better agreement with the measurements than the values from Sunatani's theory (1924); the angular displacement has been proved to be independent of the radius of the center line of the tube.

From author's summary by M. Schäfer, Germany

2324. Edmunds, H. G., Stress concentrations at holes in rotating discs, *Engineer, Lond.* **198,** 5154, 618–620, Nov. 1954.

In 1940, Teverovsky published a paper which described a photoelastic investigation of the stress concentrations at eccentric holes in flat rotating disks. The normal photoelastic method was employed, and the models were observed during rotation by means of a stroboscope. A compensator was used to measure the low fringe orders involved. The present article describes further tests which were made between 1947 and 1950 in the Engineering Laboratories of the University of Cambridge, using the frozen stress technique. Only twelve disks were tested, but the models were designed to facilitate a critical examination of Teverovsky's results. From author's summary

Buckling Problems

2325. Salvadori, M. G., Lateral buckling of eccentrically loaded I-columns, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. no. 607, 22 pp., Jan. 1955.

Critical combinations of thrust and end moments for the lateral buckling of I-columns are presented as interaction curves. The columns are free to rotate in the plane of the web and are either elastically restrained or totally fixed in the plane of the flanges. Twisting about the column axis is prevented. Columns with equal and unequal end moments and thrust are considered.

The results are in a form useful for design. The critical combinations of thrust and end moments for varying support conditions are readily obtained from critical values of equal end moments for a simply supported column.

A plot of the ratio of the axial thrust to the minimum Euler load, as a function of the ratio of the bending moment with thrust to the bending moment without thrust, is a straight line for most practical columns. This linear relation was found when the reduction of torsional rigidity was included in the analysis.

E. D'Appolonia, USA

2326. Ramamritham, S., and Kameswara Rao, A., A note on effects of face-material properties in sandwich panels under compression, *J. aero. Soc. India* **6,** 4, 88–94, Nov. 1954.

For sandwich panels under compression, increases in face material strength can result in greater weight reduction than in-

creases in modulus values. The construction is likely to be heavier, however, if the advantage of higher modulus is obtained at the expense of strength. This is illustrated by a specific example of a wide sandwich strut with dural faces and expanded foam core. C. C. Wan, USA

2327. **Seidenfaden, J., Buckling of thin-walled channels in compression** (in German), *Z. Flugwiss.* **2**, 7, 169–179, July 1954.

The torsional instability of thin-walled channels is investigated using the strain energy approach. Eighteen figures are presented which give column curves for steel and aluminum channels of various flange-to-web-width ratios and for different thicknesses. H. H. Hilton, USA

2328. **Nowacki, W., The stability of rectangular plates with ribs,** *Bull. Acad. Polonaise Sci.* **2**, 2, 85–90, 1954.

Assuming that there is no friction between the ribs and the plate and making use of trigonometric series, author obtains a general solution for buckling of simply supported rectangular plates reinforced by both longitudinal and transverse ribs and compressed in both directions. Numerical examples are given for three special cases. This work, in effect, generalizes Timoshenko's solutions for the buckling of simply supported compressed rectangular plates with either longituginal or transverse ribs [S. Timoshenko "Theory of elastic stability," McGraw-Hill Book Co., 1st ed., pp. 372–382]. T. C. Lin, USA

2329. **Csonka, P., Buckling of tubes prestressed by internal overpressure** (in Hungarian), *Magyar Építöipar* **2**, 1, 15–17, 1954.

The bearing force starting the buckle of a centrally compressed bar may be calculated by the Engesser formula $P_{ko} = (\pi^2 E_o I)/l^2$. It can be demonstrated that this formula is also applicable, with minor modifications, to tubes in the enclosed space of which a positive pressure is formed by forcing in some kind of liquid. Owing to the internal positive pressure on the cross-section planes of the tube, a decrease occurs in the stress and simultaneously the shear modulus of the material of the tube will also change. If the modified value of the shear modulus is $E_1 = E_0$, then the compressing force starting the buckle will be $P_{kI} = (\pi^2 E_1 I)/l^2 = P_{ko}$. In case of completely elastic tube material, $E_0 = E_1$. Under such conditions the existence of the internal positive pressure exercises no influence whatever on the value of the bearing force $P_{ki} = P_{ko}$. *Courtesy of Hungarian Technical Abstracts*

2330. **Kaplan, A., and Fung, Y. C., A nonlinear theory of bending and buckling of thin elastic shallow spherical shells,** *NACA TN* 3212, 58 pp., 1954.

This is the report of an extensive program of theory and experiment on the buckling of shallow spherical domes. The authors begin by criticizing the equations of E. Reissner [*J. Math. Physics* 25, 80–85, 1946; 279–300, 1947] because they are linearized. To replace them, they follow a method which, for the case of a flat plate, was used by W. Z. Chien [*Chinese J. Phys.* **7**, 102–113, 1947]; thus they obtain a formidable nonlinear system. For this system they calculate the classical buckling load when the edge is clamped and the lateral load is symmetric. Their method, like Chien's, is to expand all quantities in powers of the center deflection ratio. The first resulting equation they solve explicitly in terms of ber, bei, ker, and kei functions, but for the higher approximations they have to use numerical methods.

As is well known, the classical buckling load calculated from linearized equations is too large, and to replace it von Kármán and Tsien proposed an energy criterion. The details of Tsien's subsequent modification of this theory and of the calculation within it are open to objection. For example, in applying it to the present case the authors find that it yields critical loads which are higher rather than lower than those from the classical linearized theory which it is supposed to replace. In principle, the energy criterion can never yield a higher buckling load than the classical one, and the foregoing paradox results only from mathematical errors ("approximations"). It was the authors' desire to calculate the two buckling criteria correctly and to compare them on their merits. This they were unable to do. First, while they could see inaccuracies in Tsien's formulation of his idea, they found that to improve it would be a major endeavor. Second, in their treatment of the classical theory without linearizing it, they encountered difficulties of convergence. Limiting attention to sufficiently small values of a parameter of shallowness, they find that the classical theory yields buckling loads smaller than those obtained from the linearized theory and usually called "classical," in fact, as much as 50% smaller in the range where their method works. For less shallow shells they are able to calculate curves of deflection at loads below the critical load; for some cases the maximum deflection occurs approximately halfway between the center and the edge of the shell.

From their measurements they conclude that the classical (nonlinear) theory is in agreement with experiment for their range of calculation. They suggest that the well-known discrepancies are due entirely to an improper mathematical process (linearization), not to any defect in the theory itself. However, they say that there appears to be a trend toward the energy criterion for somewhat less shallow shells. C. Truesdell, USA

2331. **Radenković, D., On the buckling of a circular arch under vertical loads,** *Bull. Acad. Serbe Sci.* **9**, 3, 5–6, 1952.

2332. **Selberg, A., Buckling of built-up wood columns** (in Norwegian), *Teknisk Ukeblad*, **99**, 45, 919–924, 1952.

An analysis is presented which allows the computation of the number of nails or bolts required on the basis of existing shear stresses to fasten together the laminations of which the built-up column of full or H-cross section exists. E. G. Stern, USA

2333. **Paris, P. C., Testing of columns with uniformly distributed transverse loads,** *Engng. J., Montreal* **37**, 8, 945–949, Aug. 1954.

Joints and Joining Methods

(See also Rev. 2381)

2334. **Udin, H., Funk, E. R., and Wulff, J., Welding for engineers,** New York, John Wiley & Sons; London, Chapman & Hall, Ltd., 1954, ix + 430 pp. $7.50.

Up to now most textbooks on welding have treated the practical application of the welding technique, presented the various welding methods, and, in certain cases, added a chapter dealing with welding metallurgy and metallography. Of the few exceptions, one can mention the great work of Erdmann-Jesnitzer: "Schweissen und Werkstoff."

The Udin book is said to be a set of lectures given at the Massachusetts Institute of Technology; if so, the students there are to be congratulated. The welding science is approached from physical and chemical-metallurgical points of view, which gives the reader a very clear picture of the processes of the different welding methods seen from the theoretical point of view. Brazing is also treated in the same way.

The book includes a chapter on "Principles of weld inspection and testing" containing a very interesting section entitled "Philosophy of weld testing."

The book also contains 63 excellent questions, written by Prof. R. A. Wyant of the Rensselaer Polytechnic Institute.

It is, however, to be observed that before reading this book one ought to have read at least two or three books dealing with applied welding, as the Udin book is very incomplete in this respect. With this reservation the book is warmly recommended for more advanced studies in the welding field.

K. A. Ringdahl, Sweden

2335. Bredzs, N., Investigation of factors determining the tensile strength of brazed joints, *Welding J.* **33,** 11, 545s-563s, Nov. 1954.

The use of brazed joints in composite fabrication depends upon the strength and integrity of the resulting system complex. Tensile strength is selected as major criterion for evaluation. Literature survey is included. An experimental program isolating joint geometry from other complicating variables is devised. Original induction-heating technique is used to prepare specimens, and tensile strength-joint thickness curves were obtained for low-carbon steel bars brazed with pure silver, pure copper, BAg8, and BAgMn.

Test data indicate tensile strength increases with decreasing joint thickness due to plastic constraint of base metal. In extremely thin joints, however, strength is reduced because of imperfections. Comparative tests with pure silver and pure copper using different base metals show increase in joint strength with increased strength of base metal. Alloying between filler metal and base metal is not always a prerequisite to a sound strong joint.

T. A. Hewson, USA

2336. Ito, S., and Honda, K., Study on flash and butt welding: (1) Temperature distribution at the beginning of constant velocity flash welding (in Japanese), *J. mech. Lab., Tokyo* **8,** 5, 157–164, Sept. 1954.

A useful formula for the temperature distribution during flash and butt welding has been established and the relationships between welding variables have become clear, and the optimum welding conditions can be obtained easily.

By comparing these derived formulas with the experimental data, the following conclusions have been obtained: (1) The effective heat generation is proportional to the clamp displacement velocity. (2) Influence of the heat radiation and cooling effect at clamps cannot be neglected. (3) There is an upper limit in the temperature distribution and this maximum temperature distribution can be represented by $v/2h^2$. (4) Regarding the flashing surface temperature as a standard, the temperature-distribution curves can be obtained according to various clamp displacement velocities and burn-off distances only by calculations without any assumptions. From authors' summary

2337. Munse, W. H., Bolted connections—Research, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. no. 650, 18 pp., Mar. 1955.

The introduction of the high-strength bolt as a structural connector has made it possible to produce structural joints which are superior to and often more economical than comparable riveted joints. However, to obtain full benefit from the use of these bolts it is necessary that they be installed with a high initial tension. The reasons for and the effects of this high tension are discussed on the basis of previous data as well as the results of static and fatigue tests which have been conducted recently on bolts and bolted connections subjected to shear and tentile loadings. From author's summary

2338. Bell, M. H., High strength steel bolts in structural practice, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. no. 651, 36 pp., Mar. 1955.

2339. Holst, H., Nailed and glued timber construction (in Norwegian), *Teknisk Ukeblad* **99,** 46, 939–944, 1952.

Nailed and glued girders, timber frames with claw-plate reinforced, nailed joints, and glued laminated structures are under discussion.

The nailed and glued HB construction system consists of nailed and glued top and bottom flanges with a web of two crosswise arranged layers of boards nailed to the chords. The lumber consumption, although requiring only 1-in. dry boards, however, is relatively large, with glueing doubtlessly preferably a factory operation.

In the claw-plate reinforced joints of timber frames, the load is transmitted by the claw plates which are pressed into the lumber with a special screw-operated press. Twisted nails made from square wire keep the jointed members in tight contact, after press pressure is released, and transmit approximately three eighths of the total joint load. E. G. Stern, USA

2340. Holback, G. E., and Burridge, S. C., A production application of structural adhesive bonding, *Aircr. Engng.* 24, 305, 224–228, July 1954.

Structures

(See also Revs. 2291, 2303, 2331, 2352, 2353, 2377, 2573)

2341. Parkes, E. W., The permanent deformation of a cantilever struck transversely at its tip, *Proc. roy. Soc. Lond.* (*A*) 228, 1175, 462–476, Mar. 1955.

Cantilever of uniform section and plastic-rigid material is analyzed to determine permanent deflections under transverse impact of concentrated mass at tip. Special cases of large and small mass of striker compared with mass of beam are examined in detail.

Theory indicates that, for heavy striker, cantilever rotates at root as in static mode of collapse. For light striker, cantilever deforms locally at tip together with some rotation at root. Experiments with model steel cantilevers agreed well with theory for points remote from tip; local deformation at tip was influenced by actual finite dimensions of striker.

G. G. Meyerhof, Canada

2342. Suhara, J., On the matrix-operational solution of fundamental equations of continuous panel structures, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 309–314.

Paper treats panel structures consisting of orthogonally intersecting girders. Longitudinal girders were assumed to be subjected to continuously distributed loads due to multitude of transverse members.

Fundamental equations are generalized and solved by matrix-operational method. Procedure is applied to ship hull structure. Results are compared with those obtained with conventional approximate methods. Considerable differences are revealed.

A.-t. Yu, USA

2343. Disario, P. C., Podolan, J. S., and Weil, N. A., The octagonal girder four column space frame, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 542, 39 pp., Nov. 1954.

2344. Borges, J. F., Structural design (in Portuguese), *Minist. Obras Publ. Lab. nac. Engen. civ. Lisboa Pub.* no. 54, 236 pp., 1954.

Recently proposed design methods are thoroughly discussed and classified according to qualitative and quantitative proba-

bility. The proper scheme of knowledge (certain, random, strategic, and uncertain) must be adapted to the characteristics of the problems. Decision rules from the random and strategic points of view are studied separately. Within the random scheme some decision rules are presented, classified by the order of increasing adequacy. It is shown that the most satisfactory decision rule calls for introduction of the notion of utility. Prevision problems of structural behavior are discussed and statistical theories are presented to determine the probability of the failure, when fragile, fibrous, or ductile materials are used, and the similarity theories for different types of ruptures are discussed (Torroja and Paez, Weibull, Freudenthal). Several types of loading are analyzed for the most adaptable knowledge scheme (gravity, wind, earthquake). Variability of the mechanical properties of materials is analyzed, especially those of steel and concrete. For concrete, nondestructive methods (ultrasonic) are recommended. The results are applied to examples: pole and tower for low- and high-tension electrical lines, earthquake-proof structures, rainwater drainage, structures in reinforced concrete. Bibliography contains 173 references. J. J. Polivka, USA

2345. Caughey, R. A., and Cebula, R. S., Constants for design of continuous girders with abrupt changes in moments of inertia, *Iowa Engng. Exp. Sta. Bull.* 176, 27 pp., 1954.

Paper presents, in form of graphs, stiffness factors, carry-over factors, and fixed-end moments for concentrated and for uniform load, for beams with abrupt changes in moment of inertia. It should be of considerable help to designers of steel and composite beams, where such changes most frequently occur. Presentation is good, although for practical use the size of the graphs might be somewhat small. E. Rathgeb, Argentina

2346. Abeles, P. W., The development of prestressed concrete in Germany, *Civ. Engng., Lond.* **49,** 479, 480; 948–950, 1089–1093, Sept., Oct. 1954.

2347. Bay, H., Vibration experiments on prestressed structures (in German), *Bautechnik* **31,** 8, 255–259, Aug. 1954.

2348. Krishna, J., and Jain, O. P., The beam strength of the reinforced concrete cylindrical shell, *Civ. Engng., Lond.* **49,** 578, 579; 838–840, 953–956, July, Aug. 1954.

2349. Orth, J., Chardonnet, E., and Meynardi, G., Study of bottom-type water intake grids (in French), *Houille blanche* **9,** 3, 343–351, June 1954.

Bottom-type water intake grids on the bottom of torrents must absorb as much water as possible over the minimum length and properly evacuate rejected stones. Systematic tests were made on a 1/5 scale model of various grid-bar profiles; superiority of a hydrodynamical profile is evidenced. The experimental results are compared with theoretical results obtained by an approximation method previously proposed by M. Bouvard [title source, **8,** 2, 1953]. From authors' summary

2350. Kaufman, S., Contour definition of prestressed continuous beam with straight line cable position (in Polish), *Inżyn. Budown.* **11,** 4, 118–122, Apr. 1954.

This paper is particularly useful to designers of prestressed structures. Author determines typical cases for cable eccentricity at critical sections of span, proportions, and for slope of the lower beam contour (assumed horizontal top). Cases solved are: (1) Symmetric beam with parabolic slopes at both ends; also limiting condition of continuous lower parabola. (2) Nonsymmetric beam with straight line slope at one end. (3) Nonsymmetric beam with parabolic slope at one end. Two and three are further discussed for the central span and the pier span. Full derivations and graphs for various length proportions are offered. Prof. Kaufman cautions that a straight line cable approach, while more practical since friction is absent, loses the advantage of transverse strengthening provided by curved cable. He shows that elimination of secondary moments, used with discretion in this method, simplifies design.

Z. W. Dybczak, Canada

Rheology (Plastic, Viscoplastic Flow

(See also Revs. 2312, 2387, 2577)

2351. Prager, W., and Hodge, P. G., Theory of perfectly plastic solids [Theorie ideal plastischer Körper] (translated into German by F. Chmelka), Wien, Springer-Verlag, 1954, x + 274 pp., 97 figs. DM 33.

See AMR 4, Rev. 4444.

2352. Keldysch, W. M., edited by (Baldin, W. A., Goldenblat, I. I., Kotschenow, W. M., Pildisch, M. J., and Tal, K. E.,) Limit design of structures [Berechnung von Baukonstruktionen nach den Grenzbeanspruchungen] (translation from Russian), Berlin, VEB Verlag Technik, 1953, 257 pp.

Limit design of structures is based on the stress distribution at rupture. It gives a closer approach to the true physical properties of the structure than classical methods in which permissible stresses are calculated on the basis of the elastic theory. The factor of safety is calculated from different sources of uncertainty, such as strength of material, the amount of load, etc. In this way a better building economy is obtained. In spite of its obvious advantages, limit design has as yet only been introduced officially in the Soviet Union.

This book is based on the Russian building code and is aimed at giving a general introduction to structural engineers. It is written in a comprehensive way and provided with numerous examples. Also, numerical values for the partial factors of safety are listed. Reinforced concrete, brickwork, reinforced brickwork, steel, and wooden constructions are treated. In the chapter for reinforced concrete, only internal force distribution is dealt with, which, as predicted by plastic analysis, is assumed to be quadrangular. Design of statically indeterminate structures according to the theory of plasticity is only mentioned in the chapter for steel constructions.

It has to be mentioned that, in this book, the invention of limit design is ascribed to Russian scientists in 1938, although the achievements of 20 years of research in this field had been surveyed at the I.A.B.S.E. Congress in Berlin as early as 1936.

G. de Kazinczy, Sweden

2353. Wierzbicki, W., Methods of determining the index of safety, *Bull. Acad. Polonaise Sci.* **2,** 2, 99–104, 1954.

2354. Bardgett, W. E., and Gemmill, M. G., Causes of variable creep strength in basic O. H. carbon steel, *J. Iron. Steel Inst.* **179,** part 3, 211–219, Mar. 1955.

Creep and allied tests have been made on samples from 58 basic open-hearth casts of carbon steel in which the aluminum additions ranged from 1 to 2½ lb/ton. The steels were selected with the object of determining the causes of variation in their creep strength. The reaction of oxygen during steelmaking was examined for ten casts in relation to aluminum recovery; it has been shown that the soluble aluminum present in the steel is a paramount factor in the variable creep behavior, while the

McQuaid-Ehn grain size is also related to it. Further consideration of these features has led to the view that the creep resistance of any of the steels correlates directly with the aluminum nitride content, which, in turn, is related to the soluble aluminum content and grain-size characteristics of the steel. From a practical point of view it would appear that steels of good creep resistance can be obtained with aluminum additions of up to $1^1/_2$ lb/ton, provided that mold additions of aluminum are limited.

From authors' summary

2355. Johnson, A. E., Frost, N. E., and Henderson, J., Plastic strain and stress relations at high temperatures, *Engineer, Lond.* **199,** 5173, 366–369, Mar. 1955.

2356. Johnson, A. E., Frost, N. E., and Henderson, J., Plastic strain and stress relations at high temperatures, *Engineer, Lond.* **199,** 5174, 403–405, Mar. 1955.

The work described in these two papers is a further portion of a general research into the short-time combined stress properties of metallic alloys. It comprises tests made to determine the plastic-strain-stress relations for a 0.17% C steel at 350 and 450 C, and an RR59 aluminum alloy at 20, 150, and 200 C, under both simple and general complex stress loading conditions. A previous paper dealt with the plastic-strain-stress relations for a magnesium alloy at 20, 50, 100, and 150 C. As in the case of the magnesium alloy, the intent of the authors has been to explore such a range of plastic strain (1 to 2% maximum) as may reasonably be expected to occur at the commencement of a normal creep test; in this sense the short-time investigation is supplementary to a combined stress-creep program. Only a section of diagrams of results is reproduced. The full set can be examined by application to the authors. From authors' summary

2357. Seeger, A., Creep of metals at high temperatures (in German), *Z. Metallk.* **45,** 9, 521–527, Sept. 1954.

A survey is given on the mechanism of creep at different temperatures, and the influence of the different types of lattice defects is discussed. At low temperatures creep is mainly due to crystallographic glide: movement of dislocations. If work-hardening takes place, transient creep results. At higher temperatures diffusion processes become the determining factor: flow at grain boundaries and climbing of dislocations (cell formation). At equilibrium between work-hardening and recovery, steady-state creep is observed. At very high temperatures there may be a quasiviscous flow by diffusion of vacancies and interstitials. Experimental work is quoted which supports the theoretical ideas. G. W. Schoeck, USA

2358. Zhukov, A. M., Rabotnov, Yu. N., and Churikov, F. S., Experimental testing of a few theories of creep (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17,** 163–170, 1953.

Creep experiments with copper are described and data obtained are compared with the predictions of two theories: the creep theory of strain hardening [Davenport, C. C., *J. appl. Mech.* **5,** A-55, 1938; Popov, E. P., *J. appl. Mech.*, **14,** A-135, 1947], and the theory of aftereffect formulated by second author in his previous papers [Rabotnov, Yu. N., *Prikl. Mat. Mekh.* **12,** p. 53, 1948; Rabotnov, Yu. N., *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* p. 789, 1948]. The general mathematical expression of this theory is

$$\varphi(\epsilon) = \sigma(t) + {}_0\int^t K(t-\tau)\sigma(\tau)d\tau$$

where author accepts (without giving any physical explanation for his choice) $\varphi(\epsilon) = A\epsilon^\alpha$ and $K(t-\tau) = k(t-\tau)^{-\beta}$ (α, β, K, and A are constants, characteristic for a given material).

Tests are carried out in the temperature range from 170 to 250 C for a number of stresses at each temperature. Duration of test was 30 hours. Also a number of tests were done with change of stress during the test.

Functions $\varphi(\epsilon)$ and $G(t)$ where $d/dt[G(t)] = K(t)$ are obtained graphically from the experimental data, and theoretical creep curves for constant as well as for variable during test stresses are built. The agreement is quite good with the experimental curves, but one should keep in mind that time of tests was comparatively short for creep experiments. W. Sylwestrowicz, USA

2359. Ridley, R. W., Creep properties of steels utilized in high-pressure and high-temperature superheater and steam pipe practice. Part III, Revision of long-time creep data for a carbon steel header and a carbon-molybdenum steel pipe, *Instn. mech. Engrs. Proc.* (*B*) **1B,** 11, 511–515, 1952/1953.

2360. Kubo, K., Plastic behavior and creep of cement mortar, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 19–24.

An expression for creep strain as the product of a function of stress by a function of time is derived. Necessary constants are found from creep-time tests of cement mortar (30-min duration) and the expression is checked by one experimental stress-strain curve taken at a constant loading rate.

H. A. Lepper, Jr., USA

2361. Schultz-Grunow, F., Exact viscosity measurements and model theory for rheology (in German), *Kolloid Z.* **138,** 3, 167–178, Oct. 1954.

Rate of shear $\dot{\gamma}$ is related to shear stress τ, its time derivative $\dot{\tau}$, and the time t by: $\dot{\gamma}/c = \Phi(\tau/A, \dot{\tau}/GC, t/t^*)$, where A, C, G, and t^* are material constants. Viscometric measurements on several non-Newtonian fluids made with capillary and rotational viscometers at various temperatures have been correlated using dimensionless parameters constructed from experimental variables and the four material constants. Disk- and cross-shaped spindles were included, and transient as well as steady conditions. The measured velocity profile in capillary flow agreed with the Prandtl-Vandrey equation [*Z. angew. Math.* **30,** 169, 1950] rather than Poiseuille. Instruments such as the Hoeppler viscometer, in which the four material constants cannot be determined, are unsuitable for rheological measurements.

I. M. Krieger, USA

2362. Steele, M. C., The plastic bending and twisting of square section members, *J. Mech. Phys. Solids* **3,** 2, 156–166, Jan. 1955.

The stress distribution and load-carrying capacity for a long square bar of rigid-plastic material subjected to combined torsion and bending were determined by numerical method based on the analytical solutions of Handelman [*Quart. J. appl. Math.* **1,** 4, 351–353, 1944] and Hill [AMR **1,** Rev. 1354]. The calculated load-carrying capacities for the cases considered were found to fall between the upper and lower bounds found by Hill and Siebel [AMR **7,** Rev. 104]. L.-W. Hu, USA

2363. Hopkins, H. G., and Wang, A. J., Load-carrying capacities for circular plates of perfectly-plastic material with arbitrary yield condition, *J. Mech. Phys. Solids* **3,** 2, 117–129, Jan. 1955.

A general theory is presented for determining the load-carrying capacity of a symmetrically loaded circular plate made of a perfectly plastic material satisfying an arbitrary yield condition. It is shown that the problem can be reduced to the solution of a first-order ordinary differential equation. For the Tresca yield

condition, previously treated by Hopkins and Prager [title source, 2, 1, 1953], this equation can be integrated exactly, but in general a numerical solution is required. This is done for a simply supported plate under a uniform load for both the von Mises and the "parabolic" yield condition. Also treated are simply supported and built-in plates satisfying the von Mises yield condition under a uniform load over a central portion only of the plate. The numerical solutions are carried out by the method of isoclines and also by an iterative procedure using the closed form Tresca solution as a first approximation.

As authors point out, their solution provides only a lower bound unless a velocity field can be associated with the given stress field by the plastic potential stress-strain law. However, they show that such a velocity field can be found by a double numerical quadrature. Reviewer's note: For the simply supported plate where these quadratures are explicitly exhibited, it is evident that the resulting velocity field will be satisfactory and hence there is no need to carry out the integrations. However, in extending the techniques to other examples, it is conceivable that the velocity field might not satisfy certain sign conditions which the authors call attention to. P. G. Hodge, Jr., USA

2364. **Kachanov, L. M., On a problem of deformation in plastic layers** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 96, 2, 249–252, May 1954.

Two cylinders (diam $2a$) are connected with a circular disk (diam $2a$, thickness $2h << 2a$). Axially symmetrical stress distribution in disk plastically strained with tensile load is investigated. Assuming $\tau = R(r/a)z/h$ (r, z, φ cylindrical coordinates) and using the stress-strain relations $(\epsilon_r - \epsilon_z)/(\sigma_r - \sigma_z) = (\epsilon_z - \epsilon_\varphi)/(\sigma_z - \sigma_\varphi) = \ldots$, author derives approximate values for stresses and displacements. H. Mussmann, Germany

2365. **Kostyuk, A. G., Stresses in a continuous rotating cylinder beyond the elastic limit** (in Russian), *Prikl. Mat. Mekh.* 18, 453–456, 1954.

Author examines the effect of elastic compressibility on the limiting speed of rotating cylinders. Expressing stress as a series expansion of powers of a small parameter, the first two sets of stress-correction terms are evaluated for a general total strain type law. Specializing to a case in which effective stress is proportional to the nth power of the effective strain, it is shown that compressibility reduces the limiting speed, except when n is large. No numerical values are given.

R. M. Haythornthwaite, USA

2366. **Moskvitin, V. V., On elastic-plastic bending of a beam** (in Russian), *Vestnik Moskov. Univ. Ser. Fiz-Mat. Estest. Nauk* 9, 5, 33–40, 1954.

The simple plastic theory for bending of beams is applied to establish moment-curvature relations for rectangular beams composed of ideal elastic linearly strain-hardening material and subject to monotonic or cyclic loading programs.

R. M. Haythornthwaite, USA

2367. **Prager, W., On slow visco-plastic flow, "Studies in mathematics and mechanics"** (presented to R. von Mises by Friends, Colleagues, and Pupils), New York, Academic Press, Inc., 208–216, 1954.

Mathematical discussion of a viscoplastic material, which is defined as a combination of a perfectly plastic solid and a Newtonian viscous liquid. A uniqueness theorem and two extremum principles are established for such materials. The conditions under which the stress field is unique are derived.

L. Nielsen, USA

2368. **Kondo, K., On the geometrical and physical foundations of the theory of yielding,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 41–47.

Author concludes that the "possibility of various types of plastic deformations has been shown by the most competent language in nonholonomic geometry and topology." Reviewer is unconvinced. D. R. Bland, England

2369. **Shinoda, J., One-dimensional consolidation of viscoelastic body,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952, Nat. Committee for Theor. appl. Mech., May 1953, 19–21.

In laboratory tests of clay, experimental values become larger gradually than the theoretical ones computed from Terzaghi's theory assuming clay to be an elastic body. This difference, called the secondary compression, is due to the viscoelastic property of clay. The author has expressed the modulus of viscoelasticity by a mechanical model and obtained good agreement between experimental and computed values.

From author's summary

2370. **Isa, T., On plastic deformation,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952, Nat. Committee for Theor. appl. Mech., May 1953, 49–50.

Author states it is necessary to treat the phenomena thermodynamically, taking the heat transfer into account. Further, the plastic behavior is essentially irreversible so that the thermodynamics of irreversible processes must be applied to it.

The mechanical equations are derived and the associated thermal effects are analyzed. From author's summary

2371. **Nagai, R., On the hysteresis loop of total moment of forces versus torsional angle, due to a plastic stress-position curve of any arbitrary function, in the case of torsion,** *Proc. 1st Japan nat. Congr. appl. Mech.* 1951; Nat. Committee for Theor. appl. Mech., May 1952, 251–255.

A method is presented to determine the area of the hysteresis loop of torsional moment and twist angle. The radius-wise stress distribution for the yielded portion of a round bar is assumed to be an infinite power series. H. Lin, USA

Failure, Mechanics of Solid State

(See also Revs. 2334, 2385)

2372. **Hyler, W. S., Lewis, R. A., and Grover, H. J., Experimental investigation of notch-size effects on rotating-beam fatigue behavior of 75S-T6 aluminum alloy,** *NACA TN* 3291, 47 pp., Nov. 1954.

This investigation was initiated to study the influence of size, particularly the notch size, on extruded 75S-T6 aluminum-alloy test specimens. Unnotched and notched specimens with five different minimum-section diameters were tested. For each size a semicircular groove was tested, and for the largest diameter specimen a V-notch was also tested. A method of surface preparation was selected that would produce comparable surface finishes in different-sized notched and unnotched specimens.

From authors' summary

2373. **Mann, J. Y., The effect of rate of cycling on the fatigue properties of 24S-T aluminum alloy,** *Aero. Res. Labs. Melbourne, Austral. Rep.* SM 188, 20 pp., Aug. 1954.

Rotating cantilever fatigue tests have been made at 21, 170, 385, 600, 1425, and 12,000 cpm to determine the effect of rate of cycling on the fatigue resistance of 24S-T aluminum alloy.

Results indicate that although rate of cycling has little influence on fatigue behavior at stresses in the region of the fatigue limit, there is an increase in life with increasing testing speed at higher stresses. This effect is most apparent at testing speeds in the order of 200 to 600 cpm. From author's summary

2374. Weibull, W., The propagation of fatigue cracks in light-alloy plates, *SAAB Aircr. Co. Linköping, TN* 25, 20 pp., 1954.

Tests at several stress levels of repeated tension on 24S-T, 75S-T, and cast Electron (Mg alloy) internally notched plates of one size showed that the rate of crack growth varied as a power of the nominal stress in the remaining material. The major source of variability was time to crack formation rather than rate of growth. On 75S-T, a kerosene coating markedly retarded crack formation. F. A. McClintock, USA

2375. Weibull, W., A new method for the statistical treatment of fatigue data, *SAAB Aircr. Co. Linköping, TN* 30, 19 pp., 1954.

Author gives means of constructing *P-S-N* diagram from about 200 observations. No treatment of the statistical variability of the estimate, such as confidence limits, is included.
F. A. McClintock, USA

2376. Buhler, H., Residual stresses in statically loaded rods (in German), *Arch. Eisenhüttenw.* **26,** 1, 51–54, Jan. 1955.

Steel rods in which residual stresses were set up by heat treating were submitted to static tension and compression tests. Measuring of residual stresses after unloading proved mechanical stress relieving occurs as soon as strains of the order of 0.2% are reached. The amount of stress relieving is 60%. Similar plastic deformations made on steel and brass rods without residual stresses did not show residuals after unloading.
W. Soete, Belgium

2377. Anonymous, Ultrasonic investigation of cracking in Kansas City floodwall (Armourdale Unit), *Wwys. Exp. Sta. Misc. Pap.* 6-72, 43 pp., May 1954.

During the Kansas River flood of 13 July 1951, the Armourdale Unit of the Kansas City, Kansas, floodwall was damaged by a reverse water load which caused cracking. Manual soundings were taken to ascertain the extent of the cracking, and a contract was let for repair of the wall stems. The Kansas City District requested verification of the manual soundings by means of a soniscope survey of the monoliths in question.

The soniscope is an instrument for measuring the transmission time of a pulsed wave through concrete. If cracking or deterioration is present, it is detected by the pulse velocity through the affected area being lower than the velocity determined for normal concrete.

The survey at Kansas City involved determination of the extent of vertical cracking in 17 monoliths.
From summary

Material Test Techniques

(See also Rev. 2375)

2378. Norén, B., Relation between compressive strength and rate of deformation in testing Swedish fir, *Sven. TräforskInst. Medd.* 54B, 8 pp., 1954; *ASTM Bull.* 202, 43–50, Dec. 1954.

According to 288 Swedish tests described, the average ultimate compression-parallel-to-grain stress for Swedish fir of 13% moisture content increases in direct proportion to the logarithm of the rate of deformation within the speed range of 0.03 to 3 mm per min.

Previous information indicated that the ultimate load is directly proportional to the logarithm of rate of stress and that the creep load is directly proportional to the logarithm of the duration of load.

The influences of variations in moisture content, specific gravity, and origin of the test specimens within the log are also presented in order to explain the relatively large variations in the test data. If the author would have corrected the test data on the basis of the known relationships between the variables involved, it might have been possible to demonstrate a better relationship of the individual test values. Such corrections were previously made with extraordinary success, as shown in *ASTM Bull.* 147, 65–72, Aug. 1947. E. G. Stern, USA

2379. Vitovec, F., Velocity of elongation of a necking tensile specimen (in German), *Öst. Ing.-Arch.* **8,** 2/3, 221–223, 1954.

With the beginning of the necking of a tensile specimen, the strain rate of the plastic zone increases with respect to the velocity of elongation of the whole specimen. The change of the strain rate affects the true stress-strain curve. The true strain rate in the necking portion has been determined as a function of the speed of elongation. The ensuing correction is found to be small for the conditions under which tests are usually carried out.
From author's summary by B. Gross, USA

2380. Findley, W. N., and Mitchell, W. I., Two machines for combined bending and torsion fatigue, *Proc. Soc. exp. Stress Anal.* **11,** 1, 203–212, 1953.

The design and features of apparatus to convert Krouse plate-bending fatigue machines and Sonntag vibratory fatigue machines for use in tests under combined bending and torsion are described.

The Krouse machine was provided with a mechanism for stopping the machine when a crack of predetermined severity developed so that results would be less influenced by the period of propagation of the cracks. The importance of this mechanism in obtaining consistency of results is illustrated by fatigue tests of an aluminum alloy and a cast iron. A mechanical technique for calibrating the machine is also described.
From authors' summary

2381. Hartman, A., Peeling test of glued light metal plates II (in Dutch), *Nat. LuchtLab. Amsterdam Rap.* M. 1940, 50 pp., 1954.

Mechanical Properties of Specific Materials

(See also Revs. 2229, 2313, 2332, 2339, 2359, 2360, 2372, 2373, 2379, 2444, 2516)

2382. Morgan, P., edited by, Glass reinforced plastics, New York, Philosophical Library; London, Iliffe & Sons, Ltd., 1954, viii + 248 pp. $10.

This reference book, edited by Philip A. Morgan, should prove to be a valuable addition to the library of a chemist, engineer, or technician interested in such material. The underlying theory of the chemistry and mechanics of the industry is well explained in fifteen chapters. Beginning with a chapter on glass fiber forms and properties, it extends through chapters covering the fundamental chemistry of resins (polyester, silicone, melamine, epoxide, and furane); chapters on catalysts, accelerators, and inhibitors and several excellent chapters on fabrication and application. The book should prove to be particularly valuable as a reference since it combines the many different vocabularies found in the chemical,

glass, and textile industries. Its coverage of the mechanical and design aspects of reinforced plastics is somewhat limited, but this can usually be found in other texts. The book will be of particular value to the novice because it treats the subject in an elementary and fundamental manner with the minimum use of the complicated and complex vocabulary which has grown up with the industry. The techniques of fabrication and molding are well illustrated and should provide a solid starting point for those interested in this phase of the industry.

R. H. Carey, USA

2383. Otto, W. H., Relationship of tensile strength of glass fibers to diameter, *J. Amer. ceram. Soc.* **38,** 3, 122–124, Mar. 1955.

The measured strength of a glass fiber is associated with the special circumstances attending its formation. Experimental evidence is presented which shows that, contrary to generally accepted belief, the strength of a fiber does not depend on fiber diameter. When fibers of different diameter are formed under controlled, nearly identical conditions, the breaking strengths are identical within the experimental limits and there is no significant effect of diameter as such.

From author's summary

2384. Alder, J. F., and Phillips, V. A., Effect of strain rate and temperature on the resistance of aluminum, copper, and steel to compression, *J. Inst. Metals* **83,** 80–86, 1954–1955.

Stress/strain curves were determined, during compression to 50% reduction of height at constant true strain rates in the range 1–40 sec^{-1}, for (1) commercial-purity aluminum from −190 to 550 C, (2) phosphorus-deoxidized copper from 18 to 900 C, and (3) a 0.17% carbon steel from 930 to 1200 C. Glasses were used as lubricants at the higher temperatures. The stress/strain curves for copper at 750 and 900 C and for steel showed a drop in stress at higher strains, unlike those for aluminum at 350–550 C, which continued at approximately constant stress above a certain strain. The stress for a given strain increased with strain rate in fair agreement with a power law. The power index n tended to increase with temperature and at higher temperatures also increased with the strain. A plot of n against homologous temperature T_H (T_H = testing temperature (°K)/m.p. (°K.)) gave a single curve for the three metals; n was small and almost constant for values of $T_H < \sim 0.55$, but increased approximately linearly with T_H above this value at a rate increasing with the strain.

From authors' summary

2385. Harris, G. T., Child, H. C., and Kerr, J. A., Effect of the composition of gas-turbine alloys on resistance to scaling and to vanadium pentoxide attack, *J. Iron Steel Inst.* **179,** part 3, 241–248, Mar. 1955.

2386. Johnson, A. E., Jr., Mechanical properties at room temperature of four cermets of titanium carbide with nickel binder, *NACA TN* 3197, 22 pp.,Aug. 1954.

Room-temperature stress-strain curves are presented for compression, tension, and shear loadings on four compositions of titanium carbide with nickel binder. Values of ultimate strength, modulus of elasticity, modulus of rigidity, Poisson's ratio in the elastic region, density, and hardness for the four materials are tabulated.

From author's summary

2387. Grossman, P. U. A., and Kingston, R. S. T., Creep and stress relaxation in wood during bending, *Austral. J. appl. Sci.* 5, 4, 403–417, Dec. 1954.

The behavior of wood as a viscoelastic material is studied. It is found that for the recoverable component of creep in wood the superposition principle probably holds. The irrecoverable flow of wood is found to be nonlinear, but to be of a different nature for different woods.

Experimental data are given and discussed.

D. ter Haar, Scotland

2388. Calhoon, M. L., Effect of sample disturbance on the strength of a clay, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 570, 16 pp., Dec. 1954.

Of the many variables that influence the laboratory test shearing strength of saturated homogeneous clays, the effect of sample disturbance (partial remolding) has received little constructive analysis in the past. It has generally been assumed that sample disturbance reduces the laboratory shearing strength and thereby results in an added factor of safety when the test results are applied to field design. Paper demonstrates, for certain clay soils of the type tested, that due to sample disturbance the actual field shear strength may be less than the laboratory test shear strength. A method of analyzing strength data is described which considers the effect of sample disturbance.

From author's summary

2389. Plowman, J. M., The workability of vibrated concrete, *Mag. Concr. Res.* no. 15, 127–130, Mar. 1954.

Paper describes a method of comparing the workability of mixes of low water content by measuring the power required to vibrate them under standard conditions. A relationship between the number of gaps in a grading and the average power demand is obtained from the energy-time curves for various mixes and types of grading. An example illustrates the use of this relationship in calculating the weight of concrete which can be vibrated on a table under given conditions.

From author's summary

2390. Anonymous, Investigation of durability of concrete exposed to natural weathering. Summary of results 1936–1953, Report no. 5, *Wwys. Exp. Sta. tech. Memo.* 6-226, 72 pp., May 1954.

Hydraulics; Cavitation; Transport

(See also Revs. 2403, 2404, 2588)

2391. Van Manen, J. D., Some aspects of cavitation criteria (in Dutch), *Schip en Werf* **22,** 1, 10–17, Jan. 1955.

Paper presents a discussion on cavitation criteria for ship propellers. Author states that the theory for ship propellers in a peripheral nonuniform velocity field and the results of experiments according to this theory, indicate it is impossible to design a propeller blade for this case, which is free from cavitation throughout a whole revolution. However, tolerating a nonerosion cavitation form opens a new possibility for efficiency improvements.

Results of experiments and theory are not yet applicable for practical use.

Author gives directions for getting a quick estimate of the onset of dangerous cavitation, assuming a uniform or a radial nonuniform velocity field. Therefore, the results of systematic experiments on ship propellers designed with the vortex theory are converted for comparison with the experiments of Burrill. Although it appears that cavitation criteria cannot be represented by a single curve, there is reasonable agreement with Burrill's experiments. The deviation is due to the fact that the cavitation criteria are, in essence, dependent on the type of propeller, in particular of the pitch ratio.

Article concludes with a calculation example and very useful conclusions for a cavitation-free design of ship propellers.

J. H. van de Stadt, Holland

2392. Eisenberg, P., Cavitation (in German), *Forschungshefte für Schiffstechnik* no. 3/4, 3–40, 1953.

A valuable survey of the broad field of cavitation research, from both the theoretical and practical aspects, including a useful bibliography. It contains the same material as two papers in English by the same author [AMR **4**, Rev. 2546; **7**, Rev. 162].

A. H. Armstrong, England

2393. Wilsey, E. F., Flow in open channels, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 466, 18 pp., Aug. 1954.

The Chézy equation for uniform flow is derived with the well-known methods of dimensional analysis, on the basis of the analogy between resistance to flow in a conduit and along a flat plate. Tranquil flow is treated separately from shooting flow, and the validity of the usual type of equation is shown with reference to a number of experimental results. For shooting flow, a formula is presented which takes into account the "natural braking" of air-entraining currents, introducing the water portion of the flow. The relation between water portion and slope is also studied, and an interpretation of the air-entraining process is given.

P. L. Romita, Italy

2394. Tults, H., Flow expansion and pressure recovery in fluids, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 567, 26 pp., Dec. 1954.

Investigating the possibility of improving the pressure recovery in flow expansions, author observed visually the separation phenomena and measured the development of velocity profiles and pressure distribution in a gradual unilaterally expanding two-dimensional rectangular test canal with varied divergence from zero degrees to 20 degrees in range of Reynolds number 5×10^4 to 3×10^5.

Two characteristic phases of separation phenomena, "instant-stop" and "separation start," and their locations in expansion were measured and photographed by flashlights.

The analysis of the data for pressure variations in longitudinal and traverse direction gives considerable information on the mechanics of flow separation.

A simple analytical dependency is established between the angle of divergence and the rate of separation at which the maximum pressure recovery in each section occurs. This permits us to predict the optimum divergence for any required rate of gradual expansion.

Experiments on improvement of pressure recovery disclosed that the pressure efficiency may be improved considerably when the separation-endangered area is connected to a by-pass, which removes the retarded flow particles and carries those in the direction of the pressure drop into the approach canal.

From author's summary

2395. Wierz, M., Friction number and roughness of commercial pipes (in German), *Technik* **9,** 5, 283–285, 287–289, May 1954.

2396. Khazhaliya, G. Ya., Steady motion of fluids in pipes slightly deviating from the cylindrical shape (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **95,** 3, 465–468, Mar. 1954.

Author deduces an approximate expression for the velocity at the boundary of a straight tube of circular, slightly variable cross section, supposing potential flow of incompressible fluid. That expression is $V = h/\pi y^2)(1 + 1/4yy'' - 1/4y'^2)$, where h is the rate of flow, y is the local tube radius, and the derivatives are taken along the tube axis.

Author refers to a work by M. A. Lavrentiev [1946, in Russian, p. 109] where an analogous expression for plane motion was given. Then he sketches an application of his formula to wave motions in elastic tubes, saying that analogous equation for plane motion was given by Rayleigh.

Reviewer believes author's velocity formula may be useful in hydraulics (nozzles, wind tunnels, etc.); and that the wave-motion theory, when elaborated, being a next approximation beyond the known "long-wave theory," could have applications in physics (capillary waves on free jets), in engineering (vibrations of tube shells), and in medicine (blood circulation, etc.).

N. Krivoshein, Argentina

2397. Barua, S. N., Secondary flow in a rotating straight pipe, *Proc. roy. Soc. Lond. (A)* **227,** 1168, 133–139, Dec. 1954.

Paper is an interesting addition to the growing literature on secondary flow. It should be of particular (academic) interest to those in the field of turbomachinery, a field in which secondary flow is especially important and not too well understood. Analysis is for laminar flow at low Reynolds numbers (small pipe diameter and low angular velocity). The motion is studied in detail, and an expression is obtained for the resistance to flow along the pipe.

J. D. Stanitz, USA

2398. N. N. Krechetovich, Transmission of water levels in reservoirs and artesian wells, *Gidrotekh. i Melior.* **7,** 1, 54–57, Jan. 1955.

Resistance of series of electrodes located at various depths is measured by a voltmeter. Length and size of coils are adjusted in every particular case to the voltmeter scale. Current of 220 V permits transmission to many scores of miles. When telephone line is used, current is reduced to 80 V; system can work for few miles.

S. Kolupaila, USA

2399. Barbe, R., and Beaudevin, C., Experimental research on the stability of a rubble-mound breakwater subjected to wave action (translated by J. C. Van Tienhoven from *Houille Blanche* **8,** 1953), *Wwys. Exp. Sta. Transl.* 54–11, 28 pp., Nov. 1954.

The Laboratoire Dauphinois d'Hydraulique has examined, in a systematic manner and within the scope of its general studies on small-scale models, the stability of rubble-mound breakwaters with protective cover layers of loose natural stones or artificial blocks, subjected to wave attack.

Following a qualitative study of the erection of such a structure by means of dumping stones in the waves, a rapid examination has been made of the influence of each of the parameters governing the stability of rubble-mound breakwaters. A general graph condenses the results obtained to date and enables preliminary design computations to be made.

From summary

2400. Durand, R., and Condolios, E., Measurement of head losses occurring in a clear water in hydraulic filling pipes (in French), *Houille blanche* **9,** 3, 377–380, June 1954.

Industrial measurement of head losses on two large-diameter pipes (580 mm and 700 mm) for Reynolds numbers between 10^6 and 10^7. The results seem to show that, for Reynolds numbers between 10^5 and 10^6, the Blasius equation would give a better reproduction of the smooth boundary turbulent flow, as compared to the Nikuradse equation.

From authors' summary

2401. Cuenod, M., and Gardel, A., New method for stabilizing the operation of hydroelectric power stations having surge tanks (in French), *Houille blanche* **9,** 3, 352–359, June 1954.

New method is described of stabilizing water surface oscillations in surge tanks by establishing a connection between the electrical load and hydraulic head. Result of tests made at the Oelberg

power station (Canton of Friburg, Switzerland) confirms the results obtained in the theoretical studies; it is possible to maintain stabilized operation of the power station although the section of the surge tank is reduced from 300 to 7 sq meters. The dimensions of a surge tank can, therefore, be chosen without paying attention to the stability of oscillations caused by governing action.

From authors' summary

2402. **Charnîi, I. A., Influx of underground water to wells and needle filters** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17**, 179–198, 1953.

Author offers a method of calculating the discharge into wells using an electrical analogy method. He also indicates a method for the calculation of the free water-table level. Calculations of needle filter to lower the water-table are given, as well as worked-out examples. A. Gordon-Foster, England

Incompressible Flow: Laminar; Viscous

(See also Revs. 2361, 2392, 2397, 2439, 2446, 2458, 2469, 2502, 2503, 2504, 2526, 2529, 2541)

2403. **Weintraub, M., Flow of fluids,** *Indust. Engng. Chem.* 47, 3, part II, 558–565, Mar. 1955.

Tenth annual review.

2404. **Oppenheim, A. K., and Hughes, R. R., Fluid dynamics,** *Indust. Engng. Chem.* **47**, 3, part II, 632–647, Mar. 1955.

Third annual review.

2405. **Bass, J., On the stochastic solutions of certain partial differential equations related to some hydrodynamic problems** (in French), *J. Math. pures appl.* **33**, 4, 295–327, Oct./Dec. 1954.

By a method of successive approximation, a series solution is found for moments of the dependent variable in J. M. Burgers' one-dimensional nonlinear equation. Physical implications are not discussed. W. V. R. Malkus, USA

2406. **Kobashi, Y., Experimental studies on compound jets (Measurements of turbulent characteristics),** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 223–226.

Excessively concise description of apparently good experimental study in low-speed wind tunnel of jet diffusion into a moving stream for a limited range of jet/stream velocities. Jet and stream geometry are not clearly defined. Hot-wire instrument is used as both anemometer and resistance thermometer (for studying temperature fluctuations from the heated jet). The latter is calibrated at three different heating current values in variable temperature wind tunnel.

Turbulence characteristics $(u^2)^{1/2}$, $(v^2)^{1/2}$, $(w^2)^{1/2}$, etc., are plotted downstream of the jet. Results support P. Y. Chou's constant shear coefficient hypothesis. This is used for further jet analysis resulting in good agreement (awaiting publication). Temperature fluctuations downstream of the heated jet are also plotted and their strict association with axial velocity fluctuations is affirmed.

Paper loses value because of extreme brevity.

R. Culver, Australia

2407. **Polhamus, E. C., A note on the drag due to lift of rectangular wings of low aspect ratio,** *NACA TN* 3324, 24 pp., Jan. 1955.

Prandtl lifting-line theory yields $C_{D_i} = C_L^2/\pi A$ for elliptical load distribution but neglects the effects of vortex sheets on chordwise loading due to induced curvature of the streamlines and is thus not applicable to low aspect ratio. The effect of angle of attack has earlier been considered by lifting-surface theory and by analogy with end plates, resulting in $C_{D_i} = C_L^2/\pi(A + \alpha)$. The difference of the two results is appreciable for $A < 1$. Tests gavé good agreement with the second formula for $C_L \leqq 0.20$. At higher C_L, apparently nonpotential flow effects cause the experimental C_{D_i} to rise more rapidly than the formula shows.

Author evaluates this difference, called profile drag due to lift. As A decreases, the chordwise pressure gradient due to α in the vicinity of the leading edge increases due to variation of induced downwash (streamline curvature). Leading edge separation, caused by adverse pressure, increases the profile drag. Using a suction-force parameter, author obtains good agreement between theory and tests for rectangular wings through an "effective" two-dimensional lift coefficient $c_l' = C_L(1 + 4/A^2)^{1/4}$. By means of this c_l', two-dimensional tests may also be used to estimate profile drag due to lift for low-aspect-ratio wings.

G. R. Graetzer, USA

2408. **Hughes, G., Friction and form resistance in turbulent flow, and a proposed formulation for use in model and ship correlation,** *Quart. Trans. Instn. nav. Arch. Lond.*, 314–341, 4 tables, Oct. 1954.

The work presented was carried out with submerged smooth flat plates and other bodies such as submerged cylinders over a wide range of Reynolds numbers. Various thickness-length-width ratios were used in the plate experiments and, particularly at low Reynolds numbers, the transition to turbulent flows was "stimulated" by square cut (right-angled) leading edge.

The physical dimensions of the test plates together with the corrected test results are presented first. Then the experimental arrangement and design detail of test equipment are given. The correlation of experimental results for plane rectangular surfaces are presented next. A new formulation for the skin friction is given for plane, rectangular surfaces and the resulting curves compared with the experimental results. The next section presents the results of experiments with submerged cylinders (effect of transverse curvature).

Then hull resistance is analyzed, breaking it up into friction, form, and free-surface resistance. Model hull experiments at low speed are discussed and a formulation of model and ship correlation proposed. The new formulation is then compared with ship estimates gained by Froude and Schoenherr methods. Two appendixes discuss the nature of the edge effect in flow over plane rectangular surfaces, and the application of proposed formulation to the "Simon Bolivar" model results.

The verbal discussion which followed the presentation of the paper, as well as the written discussions, are printed. As is to be expected, the discussion once more centered on the question of how much use naval architects could or should make of the results and methods of the aerodynamicist. Author's reply is also printed. In general, it may be said that author's experiments are accepted as very careful, but several discussions caution about the general validity of the formulation of the resistance laws proposed. T. P. Torda, USA

2409. **Scholz, N., Use of the impulse method in airfoil cascade measurements** (in German), *ZAMM* **34**, 8/9, 339–341, Aug./Sept. 1954.

A. D. Young's method of measuring profile drag by means of integrating comb [*Aero. Res. Counc. Rep. Mem.* 2257, 1948] is extended to cascades. G. Moretti, Argentina

2410. Seth, B. R., Generalized singular points with applications to flow problems, *Proc. Indian Acad. Sci.* (*A*) **40,** 1, 25–36, July 1954.

Author claims that, in many cases, the solution of a boundary-value problem can be obtained by an appropriate isolated singularity. For example, in treating potential flow he appears to claim that the flow induced by the translation or rotation of a given solid in an infinite liquid is the same as that due to a potential obtained by differentiation of the gravitational potential of the same solid, regarded as homogeneous. The author's statements are not clear and the reviewer cannot verify the examples given.

C. Truesdell, USA

2411. Imai, I., A new method of solving Oseen's equations and its application to the flow past an inclined elliptic cylinder, *Proc. roy. Soc. Lond.* (*A*) **224,** 1157, 141–160, June 1954.

General method is developed for solving Oseen equations for two-dimensional steady incompressible flow of a viscous fluid past an arbitrary cylindrical body. Method is based on fact that velocity in vicinity of the cylinder can generally be expressed in terms of a pair of analytic functions. These functions can be determined from the appropriate boundary condition by successive approximations in powers of the Reynolds number. The velocity distribution near the cylinder and its lift and drag can be obtained in the form of a power series in the Reynolds number, without recourse to manipulation of higher transcendental functions such as Bessel and Mathieu functions.

The uniform flow past an elliptic cylinder at arbitrary angle of incidence is considered as an example of the application of the method. Analytical expressions for the lift and drag (to order *Re*) are obtained; numerical calculations are made for various thickness ratios and two Reynolds numbers. The drag was found to increase slightly with increase of either thickness ratio or angle of incidence, and the lift varies inversely with thickness ratio, while as a function of angle of incidence, it has a maximum at about 45°.

From author's summary by S. Ostrach, USA

2412. Lokaĭ, V. I., Dependence of profile losses in cascades on the angle of attack (in Russian), *Izv. Akad. Nauk Otd. tekh. Nauk* no. 6, 47–52, June 1954.

For a long time the energy losses of operating blades at unrated angles of attack were determined on the basis of the known assumptions of Zeiner-Mauritz, resulting from the jet theory of gas flow and the "shock" theory of losses. Experimental investigations of recent years have shown the inconsistency of these assumptions, both quantitatively and qualitatively.

Meanwhile, there is lacking in the literature a sufficiently generalized reduction of the question of the effect of angle of attack on turbine-cascade operation.

As a result of recent work, there are obtained generalized experimental formulas characterizing the cascade operation at variable angles of attack. These formulas can be used for theoretical investigations of the variable regions of turbine operation; in particular, when the investigation is constructed by replacing the ring cascade by a plane.

From author's summary by M. D. Friedman, USA

2413. Tĭrĭshchkin, V. G., On the question of choosing a method for designing the blade length of turbine stages (in Russian), *Izv. Akad. Nauk Otd. tekh. Nauk* no. 6, 37–46, June 1954.

At present there are known a number of so-called "aerodynamic" methods for taking into account the actual flow-parameter distribution in the separate characteristic sections of gas turbine stages (in front of the guiding apparatus, in the gap between the guiding and operating blades, and beyond the operating ring) and therefore for judging the efficiency of the blading.

Characteristic for these methods is the use of the continuity and energy equations in deriving the computational formulas, for a stream tube element, and also the equilibrium condition for an element of volume of gas in the radial direction. Here, the motion of the operating body is assumed steady and axisymmetric with respect to the control sections enumerated above.

From author's summary by M. D. Friedman, USA

2414. Frank, W., Contribution to the calculation of potential flow fields (in German), *Öst. Ing.-Arch.* **8,** 2/3, 97–107, 1954.

In incompressible-fluid-flow problems, the singularities are generally distributed on the axis or mean surface of the body depending upon the particular geometry of the problem. However, author has chosen to study the flow by means of contour singularity distributions, with the "carrying curve" well within the profile of the body. After a derivation of the integral equations which determine the distribution of the potential due to the singularities, he discusses the nature and solution of these equations. The results are applied to the problem of calculating the flow past a unit circle, and dependence of the distribution function of the singularities on the location of the "carrying curve" is shown. The final application of the method is the calculation of the pressure distribution on a cylinder whose radius includes an approximation to the boundary-layer displacement thickness.

The reviewer is of the opinion that, for many applications, this contour integral technique will be useful. In particular, he feels that the method is most useful in the calculation of the flow past a body whose shape can be described by a perturbation about some simple profile generated by an elementary distribution of singularities, since in many cases the results of the present author allow the carrying curve to be chosen to simplify the computation as much as possible. E. E. Covert, USA

2415. Shestopalov, V. P., On the problem of flow of a viscous fluid about a semi-infinite plate (in Russian), *Prikl. Mat. Mekh.* **18,** 445–450, 1954.

Author uses the equations of motion expressed in parabolic coordinates to obtain the first two terms of an approximation to the stream function and gives numerical tables. The solution of this problem using parabolic coordinates has already been given by H. L. Alden [*J. Math. Physics* **27,** 91–104, 1948].

L. M. Milne-Thomson, England

2416. Hasimoto, H., Rayleigh's problem for a plate of finite breadth, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 447–452.

Rayleigh (1911) discussed the field of flow of an incompressible fluid of viscosity μ when an infinite flat plate, initially at rest, is suddenly given a uniform velocity in its own plate. Howarth (1950) discussed the same problem for a semi-infinite plate. The author discusses the same problem for a plate of finite breadth $2a$, and calculates D, the drag per unit length, as a function of the time elapsed. The zeroth approximation

$$D/(\mu w) = 4\{a(\pi\nu t)^{-1/2} + \tfrac{1}{2}\}, (\nu = \mu/\rho)$$

is satisfactory when $a > \frac{1}{2}(\nu t)^{1/2}$. (There is a misprint in Eq. 4.15.)

G. Temple, England

2417. Kiselev, A. A., and Ladyzhenskaya, O. A., Solution of linearized equations of two-dimensional unsteady flow of viscous incompressible fluids (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **95,** 6, 1161–1164, Apr. 1954.

The problem is solved using fundamental singular tensors for

the investigation of the integral equation. In another way, author has proved that the problem can be solved by Fourier series with eigenfunctions for the case of motion in a simply connected domain and flow around a finite domain when initial distribution and boundary value of velocity are given. Behavior of the solution for $t \to \infty$ is also discussed in general. (This was previously investigated only for the cases of circle and sphere.)

M. Kataoka, Japan

2418. **Reichardt, H., Straightline Couette flow around a cylindrical body** (in German), *Mitt. Max-Planck-Inst. Strömungsforschung* no. 9, 44 pp., 1954.

Author describes experimental setup for obtaining straightline Couette flow at small *Re* between two parallel walls moving in opposite directions. Excellent flow photographs round one and two cylinders placed at different distances from the moving channel walls are presented and compared to the two-dimensional streamline patterns derived by the well-known method of sources and sinks.

The importance of this paper lies in the extensive description of the experimental problems encountered by the author in order to keep the laminar flow stable. Reviewer recommends this report to all experimenters in fluid dynamics.

Y. K. Jan, Holland

2419. **Kataoka, M., Flow around a body with wake. I,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 239–243.

Author finds the complex potential of discontinuous irrotational incompressible flow past an inclined flat plate and circular cylinder when the breakaway points are arbitrarily placed on the body. No discussion is given. K. Stewartson, England

2420. **Moretti, G., Two straight profile cascades with equal pitch and no relative motion,** *Comun. Inform. Escuela super. Aerotecn. Cordoba*, 8 pp., 1953.

Mutual influence between two straight profile cascades with equal pitch and no relative motion is studied; it is pointed out that normally the influence is so small that it is not necessary to make use of rigorous conformal mapping in order to study cascades in tandem. Suggestions for the practical solutions of direct and inverse problems for cascades in tandem are made; any well-known method for a simple cascade may be used, superposing to the ordinary field some suitable cascades of vortexes.

From author's summary

2421. **Wille, R., Flow in the transient region** (in German), *Jahrb. Schiffbautech. Gesellsch.* **46**, 176–187, 1952.

A study and a comparison are made of the motion of the von Kármán vortex streets behind a cylindrical body in a stream and of the motion in the neighborhood of a jet penetrating in still water. Author measured the variation of h/l (h is the distance between the two streets and l is the distance between two vortexes in a street) for Reynolds number from 1500 to 6000. He found that in the neighborhood of the cylinder the value of h/l is the theoretical value, namely, 0.2806, but rapidly reached 0.6 when the vortexes vanished.

The study of the jet dealt with values of Reynolds number from 2000 to 17,000. L. J. Tison, Belgium

2422. **Gilman, S. F., Pressure losses of divided-flow fittings,** *Heating, Piping & Air Conditioning* **27**, 4, 141–147, Apr. 1955.

A critical evaluation is made of the nature of the pressure losses in divided-flow fittings and of the methods of analysis previously used. Available data for the straight-through section are compared and the poor agreement indicates the need for further research.

Analysis is made of the diverted-flow section of extended-plenum fittings, and the behavior of the loss coefficient curves is explained in a rational manner. Application of concepts developed yields a predicted equation for the pressure loss which is in excellent agreement with experimental results. Some of the practical aspects of the results are presented.

From author's summary by Y. S. Touloukian, USA

Compressible Flow, Gas Dynamics

(See also Revs. 2403, 2404, 2421, 2446, 2459, 2465, 2466, 2467, 2468, 2478, 2483, 2487, 2488, 2502, 2503, 2550, 2571)

2423. **Chaix, B., and Henrici, P., On the design of two-dimensional supersonic nozzles by the method of characteristics,** *J. aero. Sci.* **22**, 2, 140–142, Feb. 1955.

Note presents results of calculation of shape of characteristic line originating at the throat of a supersonic nozzle where nozzle upstream of throat can be represented by a polynomial of third degree. No details other than final formulas for the shape of this characteristic are given. Formulas are indicated to have been derived from a general power series expansion of the velocity potential in the region of the throat. Authors state that errors in direction of characteristics of at least $\pm 2°$ can result from neglecting the nonuniformities of flow in the throat.

J. S. Holdhusen, USA

2424. **Ludford, G. S. S., Two topics in one-dimensional gas dynamics,** "Studies in mathematics and mechanics" (presented to R. von Mises by Friends, Colleagues, and Pupils), New York, Academic Press, Inc., 184–191, 1954.

In theory of plane waves of finite amplitude, the case where ratio of specific heats $\gamma = 1$ plays an exceptional role. Author shows that this is due only to notation, and solution depends continuously on γ. Author states Riemann function is more closely approximated by unity when γ is nearer unity. Both results are useful for problems of pressure waves in multiatomic gases.

By ingenious indirect method, author obtains Riemann function of differential equation for x in terms of Riemann invariants, thus probably extending class of equations for which Riemann function is known explicitly. Results may also be useful for study of plane waves periodic in time.

R. E. Meyer, Australia

2425. **Stanyukovich, K. P., General solutions of the equations of gas dynamics for one-dimensional motions for a certain given equation of state or process** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **96**, 441–444, 1954.

Consider one-dimensional nonsteady flow with

$$p = (kA^2)^k(v - \sigma_1(h))^{-k}(h + h_0)^{1-2k}$$

and let $(\tau + \tau_0)(h + h_0) = 1$, $z = (\tau + \tau_0)p$, where p is pressure, v specific volume, $h = h(s)$ mass of the gas column from $x = 0$ to x, s entropy, σ_1 an arbitrary function of h, while k, A, h_0, and τ_0 are constants. Since the Lagrangian form of the equations of motion implies $\partial^2 z/\partial\tau^2 = A^2\partial[z^{-(k+1)/k}\partial z/\partial t]/\partial t$, define w by

$$\partial w/\partial t + \partial z/\partial\tau = 0, \quad \partial w/\partial\tau + A^2 z^{-(k+1)/k}\,\partial z/\partial t = 0 \qquad [*]$$

If $J = \partial(w, z)/\partial(t, \tau) \neq 0$, transform [*] by choosing w, z as

independent, t, τ as dependent variables. Let $z = (\theta/A\alpha)^\alpha$, where $\alpha = 2k/(k-1)$, and let $k = (2n+3)/(2n+1)$ for $n = -1, 0, 1, \ldots$. Then $t(\theta, w)$ satisfies a Euler-Darboux equation whose general solution in terms of derivatives of two arbitrary functions of $\theta \pm w$ is known, and τ can be found by a quadrature. After inversion to obtain $z(t, \tau)$, the particle velocity can also be found by a quadrature. The (simple wave) case $J \equiv 0$ is solved in a form involving an arbitrary function $F(z)$. The author suggests that by proper choice of A, h_0, and $\sigma_1(h)$, flows of this type may be used to approximate flows with shocks.

J. H. Giese, USA

2426. Giese, J. H., Approximate methods for computing flow fields, *Comm. pure appl. Math.* **7,** 65–77, 1954.

An account is given of calculations of steady, nonviscous, nonlinearized, axisymmetric supersonic flows carried out by the staff of the Ballistic Research Laboratories, Aberdeen, Md., on the ENIAC and ORDVAC machines. The computational method is outlined, and there is some discussion of the restrictions on both the problems which can be solved on the ENIAC and on the method of formulating them, which arise from the limited storage capacity of this machine. Some results are quoted on the magnitude of truncation errors. The list of calculations actually performed includes tables of flows about cone cylinders with cone semiangles between 5° and 50° and Mach numbers of the incident stream between 1.3 and 7.0, calculations on the supersonic parts of a family of nozzles with plane sonic surfaces, and computations of plane nozzle shapes for use in designing cams for the control system of a wind tunnel with a flexible throat. Mention is made of the present position with regard to some contemplated calculations involving three-dimensional rotational flow (e.g., yawing bodies of revolution). D. C. Pack, Scotland

2427. Holt, M., A vortical singularity in conical flow, *Quart. J. Mech. appl. Math.* **7,** part 4, 438–445, Dec. 1954.

The vortical singularity (pointed out by Ferri) in the supersonic flow past a yawed cone is analyzed. It is shown that such a singularity can arise only at points where the velocity is directed along the radial line; that, at the singularity, the velocity is many-valued and the vorticity is infinite but the pressure is single-valued. The singularity can be fitted to a general conical field behind a shock. Flow in its neighborhood can be regarded physically as that due to a pencil of vortex sheets of varying strength. From author's summary by S. H. Maslen, USA

2428. Bulah, B. M., On the theory of conical flows (in Russian), *Prikl. Mat. Mekh.* **18,** 451–452, 1954.

Author tries to determine the form of the velocity potential function $zF(r, \theta)$ near the Mach cone

$$r = r_0 = (M_0^2 - 1)^{-1/2}$$

for continuous transition from uniform flow at Mach number M_0 to conical flow, where $r^2 = (x^2 + y^2)/z^2$ and $\tan\theta = y/x$. For both the exact and a simplified nonlinearized partial differential equation for F solutions of the form

$$F = F_0 + F_\alpha(\theta)\,(r - r_0)^\alpha + \ldots, \quad \alpha > 1$$

must have $\alpha = 2$ and $\partial F_\alpha/\partial\theta = 0$. From this the author conjectures that the conical flow field must be axisymmetric.

J. H. Giese, USA

2429. Kawamura, R., and Oguchi, H., Curved shocks in pseudostationary flows, *J. aero. Sci.* **22,** 3, 210–211, Mar. 1955.

Note in Readers' Forum.

2430. Kawamura, R., Theory of the complex, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 359–364.

The complex is a machine which exchanges the pressure of a high-pressure hot gas with a low-pressure cold air. Its structure and the cycle of operation are described by Barry [AMR 4, Rev. 895]. The author shows that the cycle given in Barry's paper is not quite complete, and he presents a new complete cycle.

A. Betz, Germany

2431. Wasserman, R., and Goldstein, A. W., Shocks in helical flows through annular cascades of stator blades, *NACA TN* 3329, 27 pp., Dec. 1954.

A method is presented for calculating supersonic potential flows in annular cascades of blades by the method of characteristics. It is found that helical flows may be adjoined by helical shocks of uniform strength. This follows from the condition of free-vortex flow upstream of blade combined with that of constant Mach number normal to the shock, because the shock surface F may be written $F = f(r) + S$, where S is a linear function of tangential and axial coordinates, that is, $S = A \cdot \theta + B \cdot Z$, which describes a helical path through cascade. Coordinates r and s are transformed into characteristic coordinates ξ and η, which in turn may be exchanged in favor of Prandtl-Meyer expansion angle ν and direction angle β, allowing formulation of equations into an exact differential. Thus a relatively simple mathematical treatment is achieved which, for example, has permitted calculation of a supersonic flow through an initial shock surface and its reflection at the outer casing. Two examples of blade configuration are computed.

A considerable addition to the class of simple supersonic flows available for design has apparently been made by authors. The limitations of not being able to describe cascade geometry in forehand as well as the potential flow restriction is, in reviewer's opinion, well balanced by the relative simplicity of approach.

J. R. Schnittger, Sweden

2432. Nikol'skiĭ, A. A., Shock waves in gas-impregnated coal (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **96,** 1, 25–28, May 1954.

Paper deals with disintegration of a slab of coal by a pressure discontinuity generated in the gaseous inclusions left in the structure of the coal. Equations of conservation of mass, energy, and momentum are set up in a one-dimensional case. Conditions for which the wave either becomes degenerate or is sustained are discussed. R. Hetherington, England

2433. Glass, I. I., and Martin, W. A., Some experimental and theoretical aspects of shock wave attenuation, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, 207–220.

Paper describes series of shock attenuation experiments in a 3-in. × 3-in. interaction tube at diaphragm pressure ratios from one to ten thousand. The same channel and chamber pressure were used in all tests, the only variable being distance downstream from diaphragm.

The shock speed defect or attenuation is considered to occur in two phases: (a) a decrement due to formation, and (b) decrease due to distance traversed. Weak shocks are found to agree well with theory, whereas measured shock velocities show progressive departure from theoretical values as the shock strength increases. The contact front was also observed to accelerate after decelerating during initial formation in the case of strong shocks.

In attempting to rationalize the observed behavior theoretically, authors assume flow to consist of a viscous boundary layer and a core of inviscid flow, and that the deflect in mass flow, and

hence shock speed, is controlled by the boundary-layer displacement thickness at the contact front. Reviewer concurs with authors in that further boundary-layer measurements are needed to substantiate these assumptions.

C. E. Carver, Jr., USA

2434. Sewell, G. L., Theory of an accelerated slender supersonic airfoil, *Aero. Quart.* **5,** part 1, 52–54, May 1954.

Author's solution to the title problem consists of the linearized, steady-flow solution plus perturbation potential and vorticity terms of $O[\epsilon(Fx)]$ and $O[\epsilon F'(0)]$, where ϵ is the dimensionless acceleration, and $F(x)$ is the ordinate of the (symmetric) airfoil; terms of $O(\epsilon^2)$ are neglected. The reviewer notes that the resulting pressure on the airfoil (not explicitly calculated by the author) does not agree with the previous potential-flow solution (to which the author makes no reference) of Gardner and Ludloff [AMR **3,** Rev. 2399; also see A. Robinson, AMR **2,** Rev. 1425; C. Roumieu, [AMR **3,** Rev. 1541]. The reviewer also notes that the author's results are at variance with Cabannes' result [AMR **7,** Rev. 2904] that acceleration of a two-dimensional attached shock introduces a curvature and, consequently, a vorticity of $O[\epsilon F'(0)^3]$. These discrepancies may be due to the author's treatment of the shock conditions when $F'(0+)$ does not vanish, in which case the resulting discontinuity in $F'(x)$ at $x = 0$ leads to infinite values of $F''(0)$.

J. W. Miles, USA

2435. Sewell, G. L., A theory of uniform supersonic flow past a thin oscillating aerofoil at appreciable incidence to the main stream, *Aero. Quart.* **5,** part 3, 185–194, Sept. 1954.

Author claims to calculate, by a perturbation procedure, nonlinear effects of steady flight incidence on the forces acting on a flat, oscillating airfoil. Reviewer believes that author's procedure and results are subject to same criticism already expressed in connection with his treatment of the accelerated airfoil (see preceding review); in particular, it appears that vorticity introduced by author exceeds, in order of magnitude, that permitted by Crocco's vortex theorem. Unfortunately, author's conciseness of style and omission of intermediate equations renders it difficult to demonstrate these contentions without repeating almost the entire analysis.

J. W. Miles, USA

2436. Etkin, B., and Woodward, F. A., Lift distribution on supersonic wings with subsonic leading edges and arbitrary angle of attack distribution, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, 80–105.

A method is presented for calculating the lift distribution on supersonic wings with straight or curved subsonic leading edges and arbitrary angle-of-attack distribution. It consists essentially of a numerical integration of the linearized potential equation. No analytical formulation of the wing geometry is required, as the geometrical parameters appearing in the equations may be obtained by making use of a planform drawing of the wing with angle-of-attack contours superimposed upon it.

For other numerical integration methods to calculate pressure distributions on supersonic wings, reader could also consult paper by Linnaluoto [AMR **6,** Rev. 575] and Behrbohm [*SAAB TN* 20, 1953].

From authors' summary by T. R. Gullstrand, Sweden

2437. Loewner, C., Some bounds for the critical free stream Mach number of a compressible flow around an obstacle, "Studies in mathematics and mechanics" (presented to R. von Mises by Friends, Colleagues, and Pupils), New York, Academic Press, Inc., 177–183, 1954.

Mach number studied is lowest for which, in two-dimensional potential flow without circulation, speed of sound is reached locally on a symmetrical profile with maximum surface inclination $< \pi/2$. Author derives two upper bounds from an inequality he discovered in AMR **7,** Rev. 548. The second is purely in terms of profile geometry, depending not even on the equation of state of the gas. The dependence on maximum surface inclination, however, makes the bounds difficult to apply to round-nosed profiles, even if thin.

R. E. Meyer, Australia

2438. Kusukawa, K., On the subsonic flow of a compressible fluid past an axisymmetric slender body, *J. phys. Soc. Japan* **9,** 605–610, 1954.

The equations for axisymmetric steady irrotational flow are simplified by neglecting the square and higher powers of the flow inclination, thus assuming that the flow is one past a slender body. In spite of this simplification, the equations retain the correct form at stagnation points. They are transformed to the hodograph plane by Legendre's transformation; the resulting second-order differential equation for the associated potential functional is nonlinear. After additional approximations appropriate for slender bodies, it is formally the same as for incompressible flow. Thus, each incompressible flow pattern is formally related to a compressible one, at least approximately. It is argued that the shapes of the body contours must be nearly the same in the two related flows. Neglecting this difference of shape, the velocity distribution on a certain prolate spheroid is worked out as function of Mach number. The critical Mach numbers according to several theories are compared.

W. R. Sears, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 2406, 2483, 2522, 2527)

2439. Gough, R. H., Entrainment and turbulence in open gas streams, *Proc. phys. Soc. Lond.* (*B*) **68,** 4, 424B, 234–240, Apr. 1955.

A method of studying the entrainment of air by a moving gas stream is presented which consists, in effect, of constructing entrainment curves for specified positions within the stream. Curves such as these have not, so far as is known, been published previously. They are of interest in showing the change from laminar to turbulent flow in the stream with particular clarity. A comparison with entrainment curves for gas burners is made.

The profile of the gas flow in the region of the laminar turbulent transition region has also been studied experimentally, and a correlation obtained with the previous results.

From author's summary

2440. Eckert, H. U., Simplified analysis of turbulent boundary-layer development along cylindrical surfaces with variable free-stream Mach number, *J. aero. Sci.* **21,** 10, 695–706, Oct. 1954.

Paper treats external and internal compressible turbulent boundary-layer flow over thermally insulated cylindrical surface, where the axis is parallel to the flow direction. The main point of the analysis is that it includes the axially symmetric viscous transverse curvature effect characterized by the parameter δ/r, which is the ratio of the boundary-layer thickness to the body radius. The analysis is based upon the von Kármán integrated momentum equation. A power-law velocity profile is assumed, along with a semiempirical shear stress relation derived from incompressible flow data. Only the range where $\delta/r \leq |1|$ is considered, which allows an approximate integration of the momentum relation to be carried out.

Errata on present paper are to be found in title source, **22,** 1, 70, Jan. 1955. Reviewer should like to note that more general analytic techniques which might be of interest for the present problem have been developed by Elliott and the reviewer [*Princeton Univ. aero. Engng. Rep.* 261, Apr. 1954] for the laminar compressible boundary layer. R. F. Probstein, USA

2441. Kampé de Fériét, J., Introduction to the statistical theory of turbulence. I, II, III (prepared by S. I. Pai), *J. Soc. indust. appl. Math.* **2,** 1, 3, 4; 1–9, 143–174, 244–271, Mar., Sept., Dec. 1954.

See AMR **6,** Rev. 1346.

2442. Lachmann, G. V., Laminarization through boundary-layer control, *Aero. Engng. Rev.* **13,** 8, 37–51, Aug. 1954.

This report deals with the application of boundary-layer control (through suction) for the purpose of delaying transition. Author points out that either too little or too much suction can be detrimental. If the amount of suction is insufficient, stable laminar layers cannot be maintained; if suction thins the boundary layer too much, the effects of surface roughness will cause transition. Expressions for the correct amount of suction are derived, based on Dryden's [AMR **6,** Rev. 561] correlation of the effects of isolated roughness elements on transition. In a final section of the paper, performance of a "laminar" airplane is compared with that of a "turbulent" airplane.

Reviewer believes that the author's interpretation of Dryden's correlation is incorrect. For example, a criterion is developed which states that the height of a roughness element should be less than one half the displacement thickness in order to avoid transition at the element. However, this criterion is based on data excluding transition located at the element; such a criterion should (according to Dryden) depend on the ratio of element size to element location. Because design parameters for suction surfaces are based on this criterion, they may not be valid. Further doubt of the results stems from the fact that they are based on a correlation for isolated two-dimensional roughness elements on flat plates, whereas they are applied to airfoils with distributed roughness. G. M. Low, USA

2443. Berger, J., Study of the injection layer along a wall (in French), *C. R. Acad. Sci. Paris* **239,** 8, 581–583, Aug. 1954.

Model tests on film cooling along a porous wall were effectuated by blowing out CO_2 through a sintered bronze plate into a turbulent boundary layer of an air stream. Velocity and concentration profiles were taken and compared.

W. Wuest, Germany

2444. Dannenberg, R. E., Weiberg, J. A., and Gambucci, B. J., A fibrous-glass compact as a permeable material for boundary-layer-control applications using area suction, *NACA TN* 3388, 20 pp., Jan. 1955.

The resistance to air flow of fibrous-glass compacts suitable for boundary-layer control was measured. The flow resistance is related to the thickness and density of the fibrous-glass compacts. Constant thickness compacts with specified permeability distributions were fabricated and tested.

From authors' summary

2445. Maeder, P. F., and Carroll, J. B., On the boundary condition for the flow along a perforated wall, *J. aero. Sci.* **22,** 3, 203–205, Mar. 1955.

In transonic wind-tunnel test sections, perforated walls have been used to eliminate choking. The boundary condition at a perforated wall had been investigated earlier, both theoretically and experimentally. This note presents another theoretical treatment plus some experimental results.

From authors' summary

Aerodynamics of Flight; Wind Forces

(See also Revs. 2404, 2407, 2436, 2480, 2481, 2482, 2528)

2446. Smith, M. A., edited by, Flight handbook. The theory and practice of aeronautics, 5th ed. (Compiled by the staff of *Flight*), London, Iliffe & Sons, Ltd.; New York, Philosophical Library, 1954, 282 pp., 217 photographs and drawings, 12 illus. $6.

It is the purpose of this new Flight Handbook to provide basic information on airplanes, their engines, and a great number of associated aviation subjects. From the foreword

2447. Haskell, R. N., and Grogan, G. C., Slender bodies of low wave drag, *J. aero. Sci.* **22,** 2, 138–139, Feb. 1955.

A method to design ducted slender bodies of revolution with low wave drag is suggested. The area distribution is expanded in a power series in x, and, using slender-body approximations, the coefficients in the expansion are determined so as to minimize the wave drag. A particular class of ducted bodies, with given inlet and exhaust radii and radius slopes, is treated. In a special example computed, a 10% reduction in drag was achieved by using a fifth-degree instead of a third-degree polynomial (= the lowest possible to fulfill all geometrical requirements.)

M. Landahl, USA

2448. Schulz, W., Motion and disturbance equations in a coordinate system fixed to the airplane (in German), *Z. Flugwiss.* **2,** 7, 157–168, July 1954.

Attention is directed to the fact that the equations for the motion of an airplane in space and the equations for the disturbances, as they are used for stability calculus, can be written down in a convenient way by the matrix form. Moreover, a way is shown how the Laplace transformation can be applied to the equations for the disturbances.

From author's summary by S. Lampert, USA

2449. Kuhn, R. E., and Draper, J. W., Investigation of effectiveness of large-chord slotted flaps in deflecting propeller slipstreams downward for vertical take-off and low-speed flight, *NACA TN* 3364, 42 pp., Jan. 1955.

An investigation of the effectiveness of a wing equipped with large-chord slotted flaps and an auxiliary vane in rotating the effective thrust vector of propellers to a near-vertical direction for vertical take-off and low-speed flight has been conducted. The model consisted of a semispan wing equipped with 60 per cent chord and 30 per cent chord slotted flaps. Two large-diameter overlapping propellers, driven by electric motors, were used. The effect of wing incidence, propeller blade angle, and an auxiliary vane on the ability of the wing equipped with slotted flaps to deflect the propeller slipstreams downward were also investigated. A few tests covered an angle-of-attack range from 0° to 90° and a thrust-coefficient range representing free-flight velocities from zero to the normal range of cruising velocity.

From authors' summary

2450. McLaughlin, M. D., A theoretical investigation of the short-period dynamic longitudinal stability of airplane configurations having elastic wings of 0° to 60° sweepback, *NACA TN* 3251, 39 pp., Dec. 1954.

An analytical investigation utilizing the semirigid approach

was made to determine the effects of wing flexibility on the static and dynamic longitudinal stability of thin-wing airplanes of the type of jet bombers. In order to investigate the effects of various important parameters, the configurations were assumed to vary in wing sweep angle from 0° to 60°, in wing c.g. location from 25% mac to 45% mac, and in ratio of wing mass to airplane mass from 0.15 to 0.50.

Three degrees of freedom were assumed: (1) Vertical translation of the airplane as a whole, (2) pitching rotation of the airplane, and (3) displacement of the wing tips with respect to the fuselage due to bending of the elastic wings. The bending and twisting characteristics of the assumed wings were approximately those possessed by an actual swept-wing bomber. Solutions with simplified equations were made, but did not give the full picture.

No dynamic instability due to wing flexibility was indicated; however, the loss in static stability due to wing flexibility for configurations with 40° to 60° sweepback was serious.

W. C. Johnson, Jr., USA

2451. **Wimpenny, J. C., Stability and control in aircraft design,** *J. roy. aero. Soc.* **58,** 521, 329–348, May 1954.

Paper presents a concise summary of the stability and control problems encountered in the field of aircraft design. This summary, plus the excellent comments so typical of papers presented before the Royal Aeronautical Society, is heartily recommended to those interested in the field. Of special interest to the reviewer is the "feel diagram" presented in which areas on a plot of stick movement—and stick force—per unit aircraft response are correlated with pilots' comments of the aircraft response in delightful terms such as "soggy," "sloppy," "touchy," etc. It is regretted that this feel diagram has not been presented on a quantitative basis. With the case for the all-moving tail so well stated, one wonders why the foreign designers have been so loathe to adopt this device. S. E. Belsley, USA

2452. **Beam, B. H., A wind-tunnel test technique for measuring the dynamic rotary stability derivatives including the cross derivatives at high Mach numbers,** *NACA TN* 3347, 35 pp., Jan. 1955.

A forced-oscillation method with system damping controlled by velocity feedback is employed to obtain dynamic stability coefficients. Single-degree-of-freedom oscillations result in combined rotary motions about three axes. An interesting application of analog computing is introduced as an integral part of the data output circuit. Illustrative experimental data are presented.

J. R. Baron, USA

2453. **Schmidt, L. E., and Murphy, C. H., Effect of spin in aerodynamic properties of bodies of revolution,** *J. aero. Sci.* **21,** 12, 857–858, Dec. 1954.

Note in Readers' Forum.

2454. **Sacks, A. H., Aerodynamic forces, moments, and stability derivatives for slender bodies of general cross section,** *NACA TN* 3283, 74 pp., Nov. 1954.

This report is a critical review and an extension of the numerous investigations on the calculation of aerodynamic stability derivatives of slender bodies. It includes all first- and second-order derivatives, except the ones for the drag force, and will be of highest interest for cases with coupling between longitudinal and lateral motions.

Author starts with the wave equation for the three-dimensional velocity potential of compressible flow and solves it on the basis of the conventional slender-body theory by conformal mapping the cross sections of the wing-body configurations on a circle. The expressions for the resultant forces and moments contain squares of the derivatives of the velocity potential and prevent the use of the superposition principle. This is important if the aircraft performs a combined maneuver, as, for instance, simultaneous rolling and pitching.

For 89 stability derivatives, formulas expressing the derivative by the mapping function and the motion of the aircraft are compiled in a table. The author's nomenclature differs from the conventional terminology because he uses the condition of zero angle of attack as the undisturbed condition. The usual rolling moment due to sideslip, $c_{l\beta}{}^*$, is in his terms

$$c_{l\beta}{}^* = C_{l\beta} + \alpha C_{l\alpha\beta} + \beta C_{l\beta\beta} + pC_{l\beta_p} + qC_{l\beta_q} + rC_{l\beta_r}$$

This has the advantage that new relations between the different stability derivatives can be established which reduce the total of 325 first- and second-order derivatives to the calculation of only 35 basic cases.

As examples, the stability derivatives for two triangular wings with camber and thickness (one with a blunt trailing edge) and for two wing-body combinations (one with additional vertical fin) are calculated. The examples show that the derivatives usually called C_{Y_p} and $C_{l\beta}$ can be more than 100% in error, if the squared terms in the pressure relations are neglected.

G. W. Braun, USA

2455. **Keune, F., Lift on a bent flat plate,** *NACA TM* 1340, 15 pp., Feb. 1955. (Translation from Bericht der Aerodynamischer Versuchsanstalt Göttingen, Luftfahrtforschung, Ann. Vol., 85–87, Mar. 1936.)

2456. **Spence, D. A., Prediction of the characteristics of two-dimensional airfoils,** *J. aero. Sci.* **21,** 9, 577–587, 620, Sept. 1954.

Distributed sources representing effects of boundary layer and wake are employed for calculation of inviscid incompressible flow when displacements due to these regions are known. Lift coefficients and pressure distributions are thus more accurately calculated than when viscous effects are omitted.

Results established by Taylor, Howarth, and Preston are developed and refined into convenient computation procedure for simultaneous determination of required source strengths and flow circulation, convenient for analytical demonstration of mechanism by which boundary layers determine external flow. Computational complexity of earlier methods is avoided.

Method established applies to flows to which ideal fluid theory provides some approximation, especially airfoils having separation points close to trailing edge and actual circulation not much different from that of ideal theory. Direct experimental verification is lacking; it will be of greatest interest in reference to thin airfoils at moderate subsonic speeds. I. Michelson, USA

2457. **Critzos, C. C., Heyson, H. H., and Boswinkle, R. W., Jr., Aerodynamic characteristics of NACA 0012 airfoil section at angles of attack from 0° to 180°,** *NACA TN* 3361, 21 pp., Jan. 1955.

The aerodynamic characteristics of the NACA 0012 airfoil section are presented for an angle-of-attack range extending through 180°. Data were obtained at a Reynolds number of 1.8×10^6 with the airfoil surfaces smooth and with roughness applied at the leading and trailing edges and at a Reynolds number of 0.5×10^6 with the airfoil surfaces smooth. The tests were conducted in the Langley low-turbulence pressure tunnel at Mach numbers no greater than 0.15.

From authors' summary

2458. Truckenbrodt, E., Theoretical and experimental investigation of symmetrical swept and delta wings in uniform flow (in German), *Z. Flugwiss.* **2**, 8, 185–201, Aug. 1954.

Complete low-speed lift, drag, and moment measurements are presented for ten swept and delta wings to angles of attack beyond the lift stall for Reynolds numbers between 0.4 and 0.9 million. The swept-wing family consists of 5 constant-chord wings of 45° sweep with NACA 0012 sections and nominal aspect ratios of 1, 2, 3, 4, and 5. The delta wings have the same airfoil section and nominal aspect ratios. However, their tips were clipped to a taper ratio of 1/8. The experimental results are in good accord with lifting-line theory with the notable exception of the wing center of pressure. The discrepancy between the predicted and measured center of pressure positions is about 6% of the mean aerodynamic chord for the wings of aspect ratio 1 and about 4% for the delta wing of aspect ratio 5. The author ascribes these differences to the assumption of lifting-line theory that each chordwise strip has its center of pressure at its own quarter-chord point. He introduces an unknown moment distribution along the quarter-chord line in addition to the usual load distribution of lifting-line theory. He then computes the lift and moment distributions by solving a simultaneous set of two integral equations by numerical means. This lifting-surface theory brings the differences between measured and predicted wing centers of pressure to within 1 to 2% of the mean aerodynamic chord.

J. Nielsen, USA

2459. Grant, F. C., and Cooper, M., Tables for the computation of wave drag of arrow wings of arbitrary airfoil section, *NACA TN* 3185, 9 pp., 28 pp. tables, June 1954.

Tables and computing instructions are presented for the rapid evaluation of the wave drag of delta wings and of arrow wings having a ratio of the tangent of the trailing-edge sweep angle to the tangent of the leading-edge sweep angle in the range from −1.0 to 0.8. The tables cover a range of both subsonic and supersonic leading edges. From authors' summary

2460. Holmboe, V., Charts for the position of the aerodynamic center at low speeds and small angles of attack for a large family of tapered wings, *SAAB Aircr. Co. Linköping, TN* 27, 26 pp., May 1954.

Charts are presented for the aerodynamic center position of straight tapered wings having streamwise tips and sweptback leading edges. The method for determining the aerodynamic center is based on simple theoretical assumptions and on experimental results obtained from about forty different papers. The error to be expected is, in most cases, less than 1% of the over-all length of the wing.

The charts are in fairly good agreement with calculations carried out by H. C. Garner with Falkner's, Weissinger's, Multhopp's, and Kuchemann's theories for swept wings.

From author's summary

2461. Holmboe, V., Approximate theoretical pressure distribution due to lift and uniform pitch and roll for double-delta wings with subsonic leading edges at supersonic speeds, 1954, *SAAB Aircr. Co. Linköping, TN* 28, 21 pp., Mar. 1954.

A simple method based on the linear theory is presented for estimating the pressure distribution in the regions influenced by the leading edge kinks of double-delta wings having subsonic leading edges at supersonic speeds. The method is here applied to lift and uniform pitch and roll. The resulting expressions for the pressure coefficients are in closed forms.

The method is based on a theoretical assumption for determining the pressure in the tip region of straight tapered wings suggested by Malvestuto, Jr., Margolis, and Ribner. The principle of this assumption is to neglect the effects on the pressure coefficients from regions which, according to Evvard's equivalent area method, tend to cancel each other. The pressure coefficients thus obtained are independent of the upwash in front of the wing.

The results are generally in good agreement with the exact linear solutions obtained by Behrbohm for double-delta wings.

From author's summary

2462. Chamberlain, J., The aerodynamics involved in high speed wing design, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, 1–21.

An extremely interesting discussion of the impact of modern high-speed computing equipment on aircraft design. The possibility of exploring more fully the effects of many variables than was previously the case has led to more complex studies of aircraft design parameters. Paper outlines the methods followed in a typical design study where these computation methods are to be used. The nature of the kinds of aerodynamic data likely to be available and the organization of an appropriate wind-tunnel testing program are also discussed.

M. J. Thompson, USA

2463. Newman, B. G., Some contributions of aerodynamic theory to the understanding of aircraft behaviour at transonic speeds, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, 69–79.

Paper deals with an application of existing aerodynamic theory to a number of problems encountered in flight and wind-tunnel testing, as well as in the operation of aircraft at transonic speeds. Among the problems considered are (a) the familiar increase in over-all drag coefficient, (b) decrease in lift coefficient at constant angle of attack, (c) buffetting of airframe or controls, (d) sudden and unpredictable changes of trim. both longitudinal and lateral, (e) effects on trailing edge controls, including loss or reversal of control effectiveness, oscillations, and flutter, and (f) loss of dynamic damping.

Several interesting cases are cited where these phenomena have occurred, and explanations based on flow behavior are offered. Most of the effects are traced to various manifestations of the shock stall on wings and controls. M. J. Thompson, USA

2464. Leyds, J., Lift and moment of low aspect ratio wings in incompressible unsteady flow, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, 221–237.

Analytical refinement is made of a method by H. R. Lawrence and E. H. Gerber [AMR **6**, Rev. 534], which is only valid for symmetrical flow. While there only average values of three-dimensional lift and moment coefficients for a translating and rotating rigid flat plate are calculated, here the change of these coefficients in chordwise and spanwise directions is taken into account, using a note by H. R. Lawrence [AMR **6**, Rev. 3507].

F. Keune, Germany

2465. Behrbohm, H., The method of upwash-cancellation in linearized supersonic wing theory as applied to the double-delta wing with subsonic leading edges. I. Total lift and pitching moment in symmetrical flow conditions, *SAAB Aircr. Co. Linköping, TN* 18, 37 pp., 1953.

This report is part of a series (see also the three following reviews) that deal with the aerodynamic characteristics of double delta wings with a concave corner in the leading edge. The additional lift due to the added piece is considered to be made up of two parts, that caused by upwash cancellation and that caused by the angle of attack. The results are expressed in terms of in-

complete elliptic integrals of all three kinds. The slope of the lift curve and the center of pressure location are calculated for 256 cases.

It should be noted that Eq. (4.3) has a typographical error and the $E(k_1)$ in the denominator should be deleted.

E. E. Covert, USA

2466. Behrbohm, H., The method of upwash-cancellation in linearized supersonic wing theory as applied to the double-delta wing with subsonic leading edges. II. Velocity potential and pressure distribution at symmetrical flow conditions, *SAAB Aircr. Co. Linköping, TN* 19, 26 pp., 1953.

The pressure distribution on the double-delta wing is computed from the potential and its integral formulation derived in an earlier report (see preceding review). The results are given in a complicated closed form involving elliptic integrals of all three kinds. The pressure distribution is computed for two cases and then integrated to give the slope of the lift curves. These slopes are compared with the previous results [op. cit.] and the agreement is satisfactory.

Reviewer is of the opinion that if the computation is to be made on a high-speed computer, it may be worth while to substitute the series approximation for the elliptic integrals. If, however, a 2% error in the results is acceptable, there are simpler methods of getting the pressure distribution (see following review).

E. E. Covert, USA

2467. Behrbohm, H., A semi-numerical method for the determination of the disturbance velocity potential and the pressure distribution of double-delta wings with subsonic leading edges in supersonic flow. I. Symmetrical flow conditions, *SAAB Aircr. Co. Linköping, TN* 20, 24 pp., 1953.

The pressure distribution is found to depend upon the sum of an irrational function, an inverse trigonometric function, a line integral, and a surface integral. The line integral can be integrated numerically using standard techniques. The surface integral is more difficult to evaluate, but can be done by a special technique worked out by Linnaluoto in [AMR 6, Rev. 575]. The surface integral can be neglected if accuracy of the order of 2% or so can be tolerated. Several examples are worked out and compared with the information previously obtained (see the two preceding reviews) and the agreement is satisfactory.

E. E. Covert, USA

2468. Behrbohm, H., A semi-numerical method for the determination of the disturbance velocity potential and the pressure distribution of double-delta wings with subsonic leading edges in supersonic flow. II. Uniform pitch and roll conditions, *SAAB Aircr. Co. Linköping, TN* 21, 25 pp., 1953.

The analytic methods (see second preceding review) for computing the pressure distribution for rolling and pitching wings are exceedingly complicated if the angle-of-attack distribution of the basic wing is nonuniform. Thus the seminumerical method (see preceding review) is applied to these cases. The results of the calculation indicate that the surface integral may again be neglected as in that report.

E. E. Covert, USA

2469. Holmboe, V., The center of pressure position at low speeds and small angles of attack for a certain type of delta wings, *SAAB Aircr. Co. Linköping, TN* 13, 8 pp., 1953.

The type of wing under discussion is a delta with a concave link in the leading edge. It is called a double delta planform. The graphical method of calculating the center of pressure on a double delta wing is developed under the basic assumption that the center of pressure depends continuously upon the variation of the planform parameters. This variation is found by use of known geometric relations and some experimental data.

In the opinion of the reviewer, the method should be quite rapid, although some experience in drawing the necessary curves is required to get the accuracy claimed (1% of m.a.c.) in the text of the report.

E. E. Covert, USA

2470. Plantema, F. J., Structural problems arising from heating of supersonic aircraft (in Dutch), *Ingenieur* 66, 31, L.33–L.39, July 1954.

An elementary review is given of problems of material deterioration, thermal stresses, thermal buckling, and creep effects, illustrated by some examples taken from the literature. Various possibilities of reducing the severity of these thermal effects are briefly discussed.

From author's summary

2471. Brooks, G. W., and Sylvester, M. A., The effect of control stiffness and forward speed on the flutter of a 1/10-scale dynamic model of a two-blade jet-driven helicopter rotor, *NACA TN* 3376, 38 pp., Apr. 1955.

Although flutter is not at present a serious problem with helicopters, the blades often operate close to critical conditions for flutter, and hence it is important to know the influence of variations in the basic parameters. The model experiments under review are a valuable contribution in this respect. The flutter motion observed was predominantly blade torsion coupled with blade flapping. Tests in the hovering condition with several values of the blade-pitch-control stiffness confirmed that critical rotor speeds for flutter are raised by increasing this stiffness. The effect of the tip-speed ratio in forward flight was examined for three mass distributions of the blades. Critical rotor speeds were found to decrease slightly with forward velocity.

C. Scruton, England

2472. Gessow, A., Review of information on induced flow of a lifting rotor, *NACA TN* 3238, 16 pp., Aug. 1954.

A brief review of the available information relating to rotor inflow is presented. The available material is summarized in a table as to flight condition, type of information, source, and the reference papers in which the data can be found. Some representative aspects of some of the reference material are discussed.

From author's summary

2473. Hazen, M. E., A study of normal accelerations and operating conditions experienced by helicopters in commercial and military operations, *NACA TN* 3434, 34 pp., Apr. 1955.

An analysis is presented of the normal accelerations and operating conditions encountered by two different airmail helicopters and a military pilot-training helicopter. Tables and graphs are used to illustrate the effect of operating conditions on acceleration levels, and a summary of all NACA helicopter VGH data analyzed to date is included.

From author's summary

2474. Gessow, A., and Tapscott, R. J., Charts for estimating performance of high-performance helicopters, *NACA TN* 3323, 36 pp., Jan. 1955.

Theoretically derived charts are presented for use in predicting profile-drag—thrust ratios of rotors having hinged blades with $-8°$ twist. The charts are considered applicable to rotor-operating conditions in which high tip-speed ratios or large rotor angles of attack are encountered; however, they do not include the effects of compressibility. Limit lines showing the conditions of onset of stall are included in the charts, and the effects of blade twist on the stall limits are discussed.

From authors' summary

2475. Powell, R. D., Jr., Hovering performance of a helicopter rotor using NACA 8-H-12 airfoil sections, *NACA TN* 3237, 14 pp., Aug. 1954.

A helicopter rotor employing NACA 8-H-12 airfoil sections has been tested on the Langley helicopter test tower. Tests were made for two surface conditions, one within −0.002 in. of true airfoil contour and the other within −0.020 in. The blades within 0.002 in. of true airfoil contour showed an average decrease of 6 to 7% in total torque coefficients.

From author's summary

2476. Harrington, R. D., Reduction of helicopter parasite drag, *NACA TN* 3234, 8 pp., Aug. 1954.

A reduction in helicopter parasite drag is possible but not profitable except in those cases where high speed and long range are primary requirements. For some of the factors causing drag, reduction in parasite-drag area may result in increased weight whereas, in other cases, it does not. The final design, however, must be a compromise between the reduction of drag and the increase in weight. From author's summary

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 2435, 2446, 2471)

2477. Schnittger, J. R., The stress problem of vibrating compressor blades, *J. appl. Mech.* 22, 1, 57–64, Mar. 1955.

Paper discusses separation phenomena in blade cascades of axial-flow compressors. It is shown that the inertial coupling of the pitching and translational modes is small for current compressor design. Analysis can therefore be restricted to studies of pure translation or pure pitch.

Analysis demonstrates that conditions can occur wherein the aerodynamic lift coefficient or the aerodynamic moment experiences a finite jump and hysteresis relative to blade motion, producing a positive work integral.

Reviewer believes the body of the analysis has been largely discussed in previous work by Halfman, Johnson, and Haley [AMR 5, Rev. 1514]. J. B. Duke, USA

2478. Tuovila, W. J., Baker, J. E., and Regier, A. A., Initial experiments on flutter of unswept cantilever wings at Mach number 1.3, *NACA TN* 3312, 19 pp., Nov. 1954.

Tests were performed on 12 cantilevered, rectangular wing models over a range of mass-density parameter, e.g., and elastic axis positions. Comparison of the test results with calculations based on the two-dimensional supersonic theory of Garrick and Rubinow gave reasonable agreement. In general, the theoretical values are conservative. W. Targoff, USA

2479. Nelson, H. C., and Rainey, R. A., Comparison of flutter calculations using various aerodynamic coefficients with experimental results for some rectangular cantilever wings at Mach number 1.3, *NACA TN* 3301, 22 pp., Nov. 1954.

The experimental results obtained from tests on twelve low-aspect-ratio rectangular wings, reported in *NACA TN* 3312, 1954 (see preceding review), are used as the criteria for evaluating four methods of flutter analysis. These are: (a) section aerodynamic coefficients for rectangular wings based on *NACA TN* 3076, 1954 [AMR 7, Rev. 3312] included in a Rayleigh analysis, (b) two-dimensional coefficients in a Rayleigh analysis, (c) total force and moment coefficients for rectangular wings based on *NACA TN* 3076, 1954, in a representative section analysis; and (d) two-dimensional coefficients in a representative section analysis.

Comparison of the analytical and experimental results indicates that the use of section aerodynamic coefficients derived on the basis of three-dimensional flow, (a) above, provides the best correlation and, in general, is significantly superior to the other methods. Even with this method of analysis, however, differences between calculated and experimental results as large as 30% are obtained for some of the configurations tested.

W. Targoff, USA

2480. Robinson, A., On some problems of unsteady aerofoil theory, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, 106–122.

Uniform approach is presented which applies to the general unsteady motion of wing, where forward velocity is either constant or variable and flight path is either straight or curved. Analysis is carried out for two-dimensional incompressible flow. Some of the ideas apply also to three-dimensional conditions and to compressible flow. Considered are very thin airfoils, being deformable within reasonable limits. Some of the analytical results are compared with the theories of H. G. Küssner.

F. Keune, Germany

2481. Williams, D. E., The effect of compressibility on elevator flutter, *Aero. Res. Counc. Lond. curr. Pap.* 185, 9 pp., Mar. 1953.

The effect of compressibility on elevator flutter is investigated by using two-dimensional control surface derivatives for Mach numbers of 0 and 0.7. It is shown that compressibility may have a considerable effect when the stick is fixed, but that the effect is small when the stick is free. From author's summary

2482. Morduchow, M., Yuan, S. W., and Reissner, H., Vibrations of a helicopter rotor-fuselage system induced by the main rotor blades in flight, ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Pap. 55—S-7, 6 pp.

Based on a simplified model of the hub-fuselage structure, a theoretical analysis is made of the response of the hub and fuselage of a helicopter in flight to harmonic forces transmitted by the rotor blades to the hub both in, and normal to, the plane of rotation. The assumed structure is in the form of a plane framework with masses concentrated at the joints. Simple expressions are derived for the vibration amplitudes of the mass points as functions of the masses and natural frequencies of the hub and the fuselage. The pertinent nondimensional parameters are determined, and simple explicit conditions of resonance are derived. Numerical examples are given to illustrate the results.

From authors' summary

Propellers, Fans, Turbines, Pumps, etc.

(See Revs. 2257, 2267, 2279, 2397, 2412, 2413, 2420, 2446, 2475, 2477, 2500, 2501, 2556, 2557)

Flow and Flight Test Techniques

(See also Revs. 2323, 2361, 2418, 2423, 2433, 2445, 2446, 2452, 2478, 2501)

2483. Nagamatsu, H. T., Summary of recent GALCIT hypersonic experimental investigations, *J. aero. Sci.* 22, 3, 165–172, Mar. 1955.

A description of the GALCIT hypersonic facilities, together with a summary of the recent experimental investigations being carried out at these facilities, is presented. The more important results obtained from the air condensation studies, investigation

of laminar boundary-layer stability, and leading-edge shock-wave boundary-layer interaction investigation are given. The results of the air condensation studies indicated that, for the range of operating conditions covered, the amount of supersaturation increased as a function of Mach number. The results of the transition experiments indicated that the laminar boundary layer is extremely stable at high Mach numbers and could only be tripped when considerable air injection was applied. The leading-edge boundary-layer shock-wave interaction investigation yielded the result, in agreement with theoretical predictions, that the static pressure ratio varies linearly with the reciprocal of the square root of the Reynolds number for the particular Mach number investigated. J. Persh, USA

2484. **Haefeli, R. C., and Bernstein, H., Investigation of Mach number changes obtained by discharging high-pressure pulse through wind tunnel operating supersonically,** *NACA TN* 3258, 14 pp., Aug. 1954.

A series of tests was performed to obtain an indication of the transient-flow phenomena caused by discharging a chamber of high-pressure gas into a wind tunnel operating supersonically. Two types of gust were obtained; one had a maximum Mach number with a practically zero time duration, whereas the other had a maximum Mach number with a finite time duration depending on the specific geometry. Such a test facility is applicable as a supersonic longitudinal-gust tunnel for producing transient boost in Mach number. From authors' summary

2485. **Chapman, D. R., Some possibilities of using gas mixtures other than air in aerodynamic research,** *NACA TN* 3226, 48 pp., Aug. 1954.

A study is made of possible uses in compressible-flow research of various gas mixtures having the same specific-heat ratio as air. Such mixtures require low wind-tunnel power and have other possible applications in compressor research and firing-range research. Certain gas mixtures can be concocted which behave at wind-tunnel temperatures dynamically similar to air at flight temperatures. From author's summary

2486. **Glass, I. I., and Patterson, G. N., A theoretical and experimental study of shock-tube flows,** *J. aero. Sci.* **22**, 2, 73–100, Feb. 1955.

The purpose of the present paper is to give an integrated account of the shock tube and some of the recent theoretical and experimental studies of shock-tube flows.

The reported data for real flows are based mainly on the one-dimensional, nonstationary research work that was conducted at the Institute of Aerophysics during the past five years. Included are theoretical and experimental investigations of the origin problem, total shock-wave attenuation, normal shock reflection, simple and double shock-wave refraction, head-on collision of shock waves, head-on collision of shock and rarefaction waves, and the overtaking of two shock waves. In addition, qualitative experiments are presented on normal reflection of rarefaction waves, double refraction of rarefaction waves, head-on collision of rarefaction waves, head-on collision of shock and wire screens, and the emergence of shock and rarefaction waves from the open ends of a shock tube into the free atmosphere.

A comparison is made between theory and experiment, and the deviations are discussed. Where a theoretical treatment is lacking, the experiments are analyzed qualitatively and the flow quantities, determined from wave speed measurements, are indicated.

From authors' summary by R. L. Bisplinghoff, USA

2487. **Knight, H. T., and Duff, R. E., Precision measurement of detonation and strong shock velocity in gases,** *Rev. sci. Instrum.* **26**, 3, 257–260, Mar. 1955.

A simple system is described for determining the velocity of detonation of strong shock waves, with temperatures above 3000 K, by using the conductivity behind the wave. Wave contact is made by two 36-mil wires set 0.1 inch apart in a Teflon plug mounted in the experimental tube. When a wave passes, signals are produced across a 30-K resistor in series with these wires and a 0.001 μf capacitor charged to 300 v. Any number of circuits may be paralleled across a single signal resistor if a diode is added to each circuit to prevent signal deterioration. The arrival time of a wave at a pin can be determined with an accuracy of almost 10^{-8} sec from an oscilloscope record of the signals. The principal advantages of this system are excellent space resolution and very simple basic circuitry. An amplifier is described which can be used with an individual pin circuit to fire a thyratron and extend the range of applicability of this system to waves with temperatures as low as 1000 K.

From authors' summary

2488. **Darpas, M. J., Investigation of tunnel testing of projectile models at supersonic velocities** (in French), *Mém. Artill. fr.* **28**, 2, 297–364, 1954.

Author presents systematic study of effects of projectile geometry on aerodynamic characteristics of projectiles at supersonic velocities and various yaw angles. Analysis is based on wind-tunnel studies made in Germany, Italy, and the United States, French firing trials, and existing empirical equations. Geometric characteristics investigated are to give curvature and taper, body and base shape and size, and presence of rotating band. Aerodynamic characteristics determined are drag, lift, moment, and friction coefficients, pressure distribution, and location of center of pressure.

Results are presented in tabular and graphical form at Mach numbers of 2 and 3 and yaw angles of 0, 3, 6, and 9 degrees. From these it is possible to estimate aerodynamic characteristics of projectiles at given supersonic Mach numbers and yaw angles. Author carefully points out disagreements between coefficients derived from sources used and probable explanations.

Reviewer believes study to be a compact, well-organized treatise on the subject of experimental external ballistics; a valuable contribution to the literature. H. E. Brandmaier, USA

2489. **Remenieras, G., and Hermant, C., Electromagnetic measurement of liquid velocities** (in French), *Houille blanche* **9**, no. B, 732–746, Nov. 1954.

Authors review the theoretical principles underlying the method of velocity measurement based on the induction of electrical potentials in a fluid moving relative to a fixed magnetic field. The advantages of the method, namely, high sensitivity, linear response, and absence of inertial lag, are discussed.

Several types of apparatus developed in the authors' laboratory are described, including an electrotachymetric nozzle for measuring small velocities whose direction is known, a current meter for unbounded flows, and an electrical probe for measuring local point velocities including turbulent fluctuations.

Paper summarizes the difficulties in the practical realization of devices utilizing the electromagnetic principle.

A. K. Oppenheim, USA

2490. **Bültemann, H.-J., Concerning the temperature dependency of readings of Bourdon-type pressure gages** (in German), *Feingerätetechnik* **3**, 8, 340–343, Aug. 1954.

Author has developed a method, based upon experimentation, for evaluating the errors inherent in the use of Bourdon-tube

pressure gages at temperatures somewhat removed from normal operating temperatures. He shows, for example, that the use of a precision pressure gage on a hot summer day may result in erroneous readings due to temperature effects alone of one half the permissible commercial tolerance. This error is due to the temperature coefficient X of the coefficient of thermal expansion α of the tube material which, for the pressure gages investigated, was brass or other similar copper alloys.

It is shown, in fact, that measurements of the indicated pressure as a function of ambient gage temperature, when compared to the actual pressure (from a dead-weight tester) allows a determination of X of the tube material used in the gage. Values of X measured in this way are compared to values obtained by other investigators in a similar manner and by entirely different methods.

It is shown that if an average value of X equal to 0.00045 per degree is used for any pressure gage utilizing a copper alloy tube in calculating the temperature error, the resultant correction will be within $\pm 10\%$; a value entirely satisfactory even for precision gages. Furthermore, a knowledge of how to correct the reading of a precision gage for temperature errors allows the gage to be used over a wide range of conditions and still meet the specifications for precision established by an official certification board (the BOfM) in Germany. The use of the average value of X equal to 0.00045 per deg is necessary since it would be inconvenient and time-consuming to determine the actual value of X for each particular pressure gage.

Tentative data on the elastic hysteresis of the tube material of the pressure gages were also obtained during the experimentation. It is shown that this factor is negligible in a correctly fabricated gage until the ambient temperature exceeds about 30 C. Above this temperature it can be expected that large errors due to the unpredictable behavior of the elastic hysteresis of the gage can be expected.

The reviewer believes the treatment of the subject matter to be neat, concise, and complete so that an engineer familiar with this treatment would be able to obtain the full performance from a given Bourden-tube pressure gage, or, for that matter, from any device using the extension of an elastic tube as the sensing element. J. T. Agnew, USA

2491. Bett, K. E., Hayes, P. F., and Newitt, D. M., The construction, operation and performance of a primary standard mercury column for the measurements of high pressures, *Phil. Trans. roy. Soc. Lond.* (*A*) **247,** 923, 59–100, Aug. 1954.

The most satisfactory primary pressure gage for measuring low pressures is the open mercury column, but, for pressures above about 30*b*, the practical difficulties caused by the great height of such a column preclude its use (1 bar, abbreviated $b = 10^6$ dyn/cm^2). In order to calibrate free-piston gages at higher pressures, a column of "reduced height" has been designed and constructed which will measure static pressures up to 2500*b* with an accuracy of $\pm 0.15b$ at the maximum pressure.

From authors' summary

2492. Stevens, J. C., A more simplified Venturi tube, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. no. 678, 10 pp., Apr. 1955.

2493. Brombacher, W. G., and Lashof, T. M., Bibliography and index on dynamic pressure measurement, *Nat. Bur. Stands. Circ.* 558, 124 pp., Feb. 1955.

The circular contains a bibliography of 850 items on dynamic pressure measurement and, in less detail, on related subjects such as static pressure measurement and general information on the components of instruments. An index of the bibliography by both subject and author is included.

From authors' summary

2494. Hawkins, M. F., Jr., and Kimmel, M. L., A rotational high pressure viscosimeter, *J. Petr. Technol.* **6,** 11, 31–33, Nov. 1954.

Thermodynamics

(See also Revs. 2425, 2485, 2492, 2514, 2516, 2520, 2521, 2539, 2540, 2541, 2550, 2559, 2561)

2495. Bennett, C. O., and Smith, J. M., Thermodynamics, *Indust. Engng. Chem.* **47,** 3, part II, 664–670, Mar. 1955.

Third annual review.

2496. Mayer, J. E., Two unsolved problems of statistical mechanics, *Comm. pure appl. Math.* **8,** 1, 73–83, Feb. 1955.

Underlying practical thermodynamics, statistical mechanics endeavors to provide formulations of quantitative exactness. While general mathematical description is available for most essential questions, in many cases solutions of only the lowest order of approximation are available. The thermodynamic equation of state is ultimately dependent on the intermolecular potential which is known satisfactorily in many cases. For a medium at an arbitrary density and state, no feasible procedure yet exists for developing the thermodynamic functions from the potential. Author reviews the general statement as a multiple integral of high order and also as a matrix equation. A second problem concerns itself with states not at statistical equilibrium. In spite of the apparent success of formal theories of irreversible thermodynamics and even of first- and second-order corrections to statistical distribution functions, as yet the general nonequilibrium question is not even stated in precise terms. The difficulty seems to be associated with the definition of entropy. Under the states in question there are inadequate criteria as to what a desirable definition might be. This must be resolved before progress in the area can be significant. N. A. Hall, USA

2497. Bouman, D. J., A theory of the ventilated psychrometer based on the thermodynamics of irreversible processes, *Tellus* **6,** 4, 399–404, Nov. 1954.

The equation for adiabatic saturation is derived from the formalism of the thermodynamics of irreversible coupled flows. The classical thermodynamics is valid only for "(a) closed systems, (b) equilibrium conditions, (c) quasistatic processes, and (d) reversible processes."

In reviewer's opinion, the implication that the present treatment provides a wet-bulb temperature instead of an adiabatic-saturation temperature is unjustified. Moreover, the derivation offered is at least as questionable in validity as the classical one. For example, it includes an undefined interior heat quantity d_iQ. The author's concept of classical thermodynamics is more restricted than it need be. J. H. Keenan, USA

2498. Guthmann, K., Tolerances and errors in temperature measurements with thermocouples (in German), *Arch. Eisenhüttenw.* **25,** 11/12, 535–561, Nov./Dec. 1954.

Paper summarizes the empirical information found scattered through the literature on the errors and tolerances involved in the measurement of temperature by means of thermocouples. It describes the standardized types of thermocouples, their usage, and their application, as well as the physical properties of the materials utilized for this purpose. The type, cause, magnitude, direction as well as the correction for most common errors inherent to thermocouples are listed and individually discussed. A nomogram for correction of the errors due to change in resistance with temperature variations, and different circuits for error

compensation are presented. The influence of the reference joint on the accuracy of the measurement and the means of proper mounting of the thermocouples for particular applications are illustrated. The errors in the thermocouple operation due to age and the errors affected by additional galvanic currents, as well as the inaccuracy originating from the measuring instruments are discussed. Protective tubes for thermocouples, metallic and ceramic, and the effect of gas permeability of such tubes at higher temperatures are briefly discussed.

D. Kurtovich, USA

2499. **Lee, C. Y., and Wilke, C. R., Measurements of vapor diffusion coefficient,** *Indust. Engng. Chem.* **46,** 11, 2381–2387, Nov. 1954.

Diffusion coefficients D of binary gas mixtures were carefully determined by means of the Stefan technique, in which one component in the liquid state is placed in the bottom of a vertical tube across the mouth of which the second gaseous component is blown. End effects caused by slight turbulence at the mouth of the tube and by curvature of the liquid meniscus were determined experimentally by extrapolating the apparent values of D to infinitely long diffusion paths. The former effect is the more important of the two and corresponded to a reduction in the effective diffusion path of zero to 0.7 tube diameters. This end effect depended strongly on the gas velocity past the tube's open end and was apparently larger for liquids of lower vapor pressure. The slight lowering of the interfacial temperature owing to the latent heat of evaporation was observed experimentally and appropriate corrections were applied. The effect of natural convection in the supposedly stagnant gas column was observable in large-diameter tubes when the vapor released at the bottom of the gas column was lighter than the gaseous component.

At 760 mm and 25 C, the finally corrected values of D were: 0.0962 cm²/sec for benzene, 0.135 for ethanol, 0.0855 for nitrobenzene, and 0.260 for water in air; 0.0385 for benzene, 0.0475 for ethanol, and 0.105 for water in Freon-12; and 0.384 for benzene, 0.494 for ethanol, 0.372 for nitrobenzene, and 0.908 for water in helium.

R. L. Pigford, USA

2500. **Esgar, J. B., and Ziemer, R. R., Methods for rapid graphical evaluation of cooled or uncooled turbojet and turboprop engine or component performance (effects of variable specific heat included),** *NACA TN* 3335, 45 pp., Jan. 1955.

Over-all cycle performance of turbojet and turboprop engines may be calculated by use of a series of curve sheets, each relating the parameters affecting a single component of the engine. The curves are based on combustion gases for hydrogen-carbon ratio of 0.167, including the effects of variable specific heat but not including any dissociation. The curves cover a range of flight Mach numbers from zero to 3.0, compressor ratios from 1 to 30, turbine inlet temperatures from 1500 R to 3000 R, and afterburner temperatures from 2800 R to 3500 R. Procedures are also presented for including the effect of turbine cooling with compressor bleed air.

These charts provide a very useful tool for calculating engine performance.

W. M. Rohsenow, USA

2501. **Simmons, F. S., Analytic determination of the discharge coefficients of flow nozzles,** *NACA TN* 3447, 15 pp., Apr. 1955.

Author assumes a velocity profile $u/u_0 = \tanh(ay)$ for the boundary layer, and integrates the laminar incompressible momentum equation. The resulting ratio of boundary-layer thickness to nozzle radius is insensitive to the assumed profile and to the exact choice of the origin of the boundary layer. In view of the assumptions, the resulting discharge coefficient is in remarkable agreement with the experimental data of B. O. Buckland [*Trans. ASME* **56,** 11, 827–832, Nov. 1934], the difference between theory and experiment being less than 0.5% in the Reynolds number range 10^4 to 10^6. Author states that compressibility effects are small compared with those included in the analysis and concludes that results will hold for compressible flows.

Using the Reynolds analogy, the modification in the discharge coefficient due to heat transfer from an isothermal nozzle wall is calculated.

W. Daskin, USA

2502. **Kämmerer, C., Flow in a nozzle with frictional resistance** (in German), *Öst. Ing.-Arch.* **8,** 4, 293–306, 1954.

It was Zeuner, a German scientist, who introduced in the 19th century a very worth-while conception of the polytropic process, in which the specific heat remains constant, any constant value being permissible. It is obtainable by integration of the first equation of thermodynamics under this assumption, and so it is a reversible process accompanied by heat exchange with the surroundings. Later, some other German workers introduced, unfortunately, an erroneous conception of a "real, irreversible process" identified mathematically with the polytrop. It has since then been shown a number of times that the latter conception is physically inadmissible (see, e.g., the following review), especially in the case of flow through a nozzle, this flow being nearly adiabatic. However, the ugly ghost still continues to reappear in scientific publications. The paper under review is a further example thereof. As soon as the reader comes to the point at which polytropic form of a real process, bound with friction, is introduced, he is discouraged with the study of the remainder of the paper.

B. Szczeniowski, Canada

2503. **Szczeniowski, B., The critical flow of gases through nozzles,** *Aircr. Engng.* **24,** 2 pp., June 1952.

Objection is made to the use of the polytropic relation to represent irreversible processes such as one-dimensional frictional flow through nozzles. Author defines a polytrop as a "reversible process, with heat exchange, in which the specific heat remains constant." He derives a steady-flow energy equation by adding together the two equations

$$dQ = c_v dT + (1/J)Pdv$$

and

$$vdP + (1/g)wdw = (v/A)dF$$

where dF may be a frictional force applied by the wall.

In the reviewer's opinion, the polytrop is simply a relation between P and v with no implication about variation in specific heat. It may be applied to a nonperfect gas. For reasons of utility it may also be applied to the flow of a perfect gas through a Joule-Thomson plug, although here a question of continuity of states arises. Author's treatment is not clarifying for many reasons, including the following: though Q appears to be not necessarily zero in an adiabatic process, neither Q nor adiabatic is defined. The stationary wall is considered to be imparting work to a gas flowing by because the frictional force is "being displaced with the velocity of flow." It appears that the wall can impart work without suffering any loss of energy.

J. H. Keenan, USA

2504. **Westley, R., A bibliography and survey of the vortex tube,** *Coll. Aero. Cranfield Note* 9, 38 pp., Mar. 1954.

2505. **Rutherford, W. M., and Drickamer, H. G., Theory of thermal diffusion in liquids and the use of pressure to investigate the theory,** *J. chem. Phys.* **22,** 7, 1157–1165, July 1954.

Authors present a theory of thermal diffusion in liquids based

upon the thermodynamics of irreversible processes, in which the concentration gradients resulting from temperature gradients are expressed in terms of the "heats of transport." The latter are substituted in terms of a molecular description based on the theory of regular solutions presented by K. G. Denbigh [*Trans. Faraday Soc.* **48**, 1, 1952]. A modification of Denbigh's results is derived in which the effect of differences of molecular shape and size are accounted for.

Measurements of the thermal diffusion coefficient for various binary mixtures under pressures up to 10,000 atmospheres are described, the results of which reasonably substantiate the theory. L. M. Grossman, USA

2506. Saxton, R. L., Dougherty, E. L., and Drickamer, H. G., Thermal diffusion in binary liquid mixtures of molecules of simple symmetry, *J. chem. Phys.* **22,** 7, 1166–1168, July 1954.

An extension of work described in preceding review in which thermal diffusion measurements are presented for a series of binary solutions with molecules of approximately the same size and shape over a range of temperatures from 5 to 55 C. The theory developed in the previous paper applies quite satisfactorily for the solutions investigated. L. M. Grossman, USA

2507. Grew, K. E., Johnson, F. A., and Neal, W. E. J., The thermal diffusion factor and temperature, *Proc. roy. Soc. Lond.* (*A*) **224,** 1159, 513–526, July 1954.

The thermal diffusion factor has been measured for several gas mixtures in a range of temperature which included that at which the reversal of sign, predicted theoretically when a Lennard-Jones type of interaction is assumed, might be observed. A reversal was found with hydrogen-deuterium, nitrogen-argon, oxygen-argon, and nitrogen-carbon-dioxide mixtures; with neon-argon, argon-krypton, and krypton-xenon mixtures no reversal was observed, the thermal diffusion factor having a small positive value at the lowest temperatures at which measurements could be made. A comparison of the experimental values of the thermal diffusion factor with values calculated for the Lennard-Jones model shows that this model is not quantitatively satisfactory.

From authors' summary

2508. Nettley, P. T., The approach to the steady state in gaseous thermal diffusion and its application to determining the dependence of gas diffusivity on the concentration ratio, *Proc. phys. Soc. Lond.* (*B*) **67,** part 10, 418B, 753–760, Oct. 1954.

From measurements of the rate of approach of a thermal diffusion cell toward a steady state, the coefficient of ordinary diffusion D was computed for mixtures of hydrogen and nitrogen, based on a previous theory of Jones and Furry [*Rev. mod. Phys.* **18,** p. 163, 1946]. The cell employed for the experiments consisted of a heated chamber placed vertically above a cold one, the two being connected by a short tube within which the concentration gradients were developed. The observed time constant for the apparatus varied from 7.30 to 8.13 min as the percentage of hydrogen in the mixture increased from 6.4 to 82.7, corresponding to values of D ranging from 0.81 to 0.74 cm²/sec, respectively, at 15 C and 1 atm.

Although the absolute magnitude of the ordinary diffusion coefficients determined in this way may be subject to error, owing to inexact assumptions regarding the transient behavior of the apparatus, the observed variation of D with composition should be reliable. The influence of composition appears in the second approximation to D from kinetic theory and is dependent on the law of forces between molecules. The observed effect was greater than would have been expected for rigid, elastic spheres, for which the influence of composition on D is greater than for softer molecules. R. L. Pigford, USA

2509. Mossop, S. C., The freezing of supercooled water, *Proc. phys. Soc. Lond.* (*B*) **68,** part 4, 424B, 193–208, Apr. 1955.

To investigate the freezing of supercooled water of high purity, measurements were made of the freezing point of samples of water in glass capillary tubes, both with and without a hydrophobic coating on the walls. These showed the difficulty of excluding freezing nuclei that originate in room air. A simple technique was therefore devised for preparing uncontaminated specimens of water in glass or fused silica tubes. Samples prepared in this way froze at temperatures consistently lower than any previously recorded for similar volumes of water. The lowest value obtained for water in glass was −34.5 C for a volume of 6×10^{-4} cm³. It is shown that some of the results of previous workers can be accounted for by the presence of foreign freezing nuclei in the water used. The relationship between volume and freezing point for spontaneous nucleation is discussed in the light of experimental result.

From author's summary

2510. Whalley, E., Thermodynamic properties of argon in the temperature range −100 to +600° C. and pressure range 0 to 80 atmospheres, *Canad. J. Technol.* **33,** 2, 111–116, Mar. 1955.

The values of PV in the temperature range −100 to +600 C and specific heats, enthalpy, entropy, and Joule-Thomson coefficient, in the temperature range 0 to 600 C have been calculated for argon in the pressure range 0 to 80 atm, using the compressibility data presented in a previous paper.

From author's summary

2511. Webber, H. A., Goldstein, D., and Fellinger, R. C., Determination of the thermal conductivity of molten lithium, *Trans. ASME* **77,** 2, 97–101, Feb. 1955.

See AMR **7,** Rev. 2287.

2512. Brandt, F. A., Bishop, H. F., and Pellini, W. S., Solidification of various metals in sand and chill molds, Amer. Foundrymen's Soc. Ann. Meet., Cleveland, Ohio, May 1954. Prepr. 54–62, 7 pp.

2513. Locke, C., and Briggs, C. W., Heat transfer of various molding materials for steel castings, Amer. Foundrymen's Soc. Ann. Meet., Cleveland, Ohio, May 1954. Prepr. 54–61, 11 pp.

Heat and Mass Transfer

(See also Revs. 2423, 2443, 2470, 2495, 2497, 2498, 2499, 2504, 2505, 2506, 2507, 2508, 2511, 2512, 2513, 2555, 2560, 2561)

2514. Eckert, E. R. G., Hartnett, J. P., and Isbin, H. S., Heat transfer, *Indust. Engng. Chem.* **47,** 3, part II, 647–658, Mar. 1955.

Third annual review.

2515. Jaeger, J. C., and Beck, A., The calculation of heat flow through disks and its application to conductivity measurements, *Brit. J. appl. Phys.* **6,** 1, 15–16, Jan. 1955.

A common method of finding the thermal conductivity of rocks or other materials involves the axial flow of heat through a number of cylinders. When the sample disk is not the same diameter as the cylinders of the apparatus, an error in the conductivity measurement can result.

The present paper describes a numerical method for solving the general problem of disks and rods of different sizes and conductivities, and gives an exact solution of the case where constant heat flux over the contact circle is assumed. The error found by

analysis from the exact solution checks closely with the error due to different-sized test disks found experimentally.

Reviewer believes the result will be especially useful for researchers using multiple-cylinder methods for determining heat conduction. R. H. Eustis, USA

2516. Powell, R. W., Thermal conductivities of solid materials at high temperatures, *Research, Lond.* **7,** 12, 492–501, Dec. 1954.

The author, a leading contributor to the field, reviews the published measurements (53 references) of thermal conductivity of metals, alloys, cermets, polycrystalline oxides, carbon and graphite, quartz, silica, rocks, and glasses. The data are presented in plots from which only approximate values can be read. Where data for steels and other alloys are reported, tables give the chemical compositions. Composite plots show a tendency for certain groups of materials to converge toward a common value at high temperatures. J. Hilsenrath, USA

2517. Heisler, M. P., Temperature charts for internal heat generation, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-44, 10 pp.

Author presents a series of twelve graphs which permit convenient solution of transient heat-flow problems involving uniform internal heat sources. The cylinder, plate, and sphere are treated for a broad range of the characterizing parameters.

The charts cover Fourier's modulus and relative boundary resistance over the full range from 0 to ∞. The position variable is also covered except for values of the Fourier modulus below 0.2, in which range only the case of zero boundary resistance is treated.

These charts should be as useful in their field as the Gurney-Lurie charts have been in external source-sink problems. The charts should be useful in nuclear energy, electrical and electronic processes, metallurgical heat-treatment, chemical curing, wood laminating, dielectric and resistance heating problems.

F. C. Hooper, Canada

2518. Thermal conductivity: Kingery, W. D., and McQuarrie, M., Concepts of measurement and factors affecting thermal conductivity of ceramic materials; Adams, M., and Loeb, A. L., Development of a thermal conductivity expression for the special case of prolate spheroids; Adams, M., Prolate spheroidal envelope method; Data for Al_2O_3, BeO, MgO, ThO_2, and ZrO_2; Francl, J., and Kingery, W. D., Apparatus for determining thermal conductivity by a comparative method; Data for Pb, Al_2O_3, BeO, and MgO; McQuarrie, M., High-temperature method and results for alumina, magnesia, and beryllia from 1000 to 1800 C; Kingery, W. D., Determination of conductivity of Al_2O_3 by spherical envelope and cylinder methods; McQuarrie, M., Analysis of variation of conductivity with temperature for Al_2O_3, BeO, and MgO; Loeb, A. L., A theory of thermal conductivity of porous materials; Francl, J., and Kingery, W. D., Experimental investigation of effect of porosity on thermal conductivity; Kingery, W. D., Francl, J., Coble, R. L., and Vasilos, T., Data for several pure oxide materials corrected to zero porosity, *J. Amer. ceram. Soc.* **37,** 2 (part II), 67–110, Feb. 1954.

2519. McNall, P. E., Jr., and Janssen, J. E., An electrolytic analog applied to the solution of a thermal conduction problem, ASME Semi-Annual Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-45, 16 pp.

An application of the electrolytic-tray analog to heat-transfer problems dealing with removal of heat from power transistors. In order for the analog solution to be that of the problem to be solved, not only the differential equation but also the boundary conditions must be the same in both cases. In most germanium transistor operations, the heat generation is a function of time and space. The assumption made by the authors of steady-state heat generation may not bring serious consequences in most instances.

Authors also assume constant thermal properties throughout the germanium base. Since the thermal conductivity of germanium is very sensitive to temperature, this fact makes the problem nonlinear and the simple analog solution of Poisson's equation will not give the actual temperature field. Another point the reviewer would like to make is that the boundary conditions of the actual problem are not well defined. The measured flow lines from the analog show that the heat generation is evacuated from only one face of the brass and aluminum heat conductors. If heat is removed from that face, by convection, then why is convection neglected on the remaining larger faces?

S. Eskinazi, USA

2520. Mizushima, S., Thermal conductivity of crystals and liquids, *J. phys. Soc. Japan* **9,** 4, 546–552, July-Aug. 1954.

Thermal conductivity of crystals without defects is calculated on the approximation that the mutual collisions of phonons of the normal type occur far more frequently than the Umklapp collisions. The conductivity K for crystals at temperatures not too low below the characteristic temperature and above is expressed as $K \sim 0.1(qa(U/V)/(QT)$, where q is the sound velocity, a the lattice constant, U/V the cohesive energy per unit volume, T the absolute temperature, and Q is a number of the order of unity introduced to take into account the difference of the crystal structure. This formula fits fairly well to observed values for ionic crystals having NaCl-type lattice and, furthermore, applies equally to the conductivity of liquids. In the latter case, it is shown that the above formula is approximately identical with the well-known formula proposed by Bridgman.

From author's summary

2521. Callan, E. J., The thermal properties of mass concrete as influenced by the aggregates, "Aggregates for mass concrete," *Wwys. Exp. Sta. Bull.* 39, 18–32, Aug. 1954.

The principal thermal considerations which must be properly evaluated in the production of good, durable mass concrete are the temperature rise, the coefficients of thermal expansion, and the thermal diffusivity. Other thermal properties are related to this problem in a minor way although their effects are not completely understood.

To secure the best possible mass concrete from the standpoint of thermal properties, the use of mixtures of low cement factor with properly selected aggregates of low diffusivity and fairly high specific heat is most desirable. With such mixtures, thermal stresses and cracking may be reduced to a considerable degree or rendered entirely negligible. This control and prevention are the basic task involved in the determination and evaluation of the thermal properties of mass concrete.

From author's summary

2522. Bayley, F. J., An analysis of turbulent free-convection heat-transfer, *Instn. mech. Engrs.*, 3–10, 1955.

A theoretical analysis is made of steady-state heat transfer from a vertical flat plate having a uniform temperature to the adjacent turbulent free-convection boundary layer. The Nusselt modulus is related to the boundary-layer thicknesses by a two-region analysis in which the eddy diffusivity is assumed to be uniform in the turbulent region and the interface is defined by $y^+ = 15$. The boundary-layer thicknesses are then computed

using the integrated momentum and heat boundary-layer equations as they were employed by Eckert and Jackson [AMR **4**, Rev. 2706] in the solution of this same system for a Prandtl modulus near unity.

The present work extends the Eckert-Jackson analysis to include the low Prandtl modulus range, i.e., liquid metals. The analysis agrees with the air data, but there are no liquid metal data available with which to compare it.

Reviewer believes it to be a commendable first attempt at this very difficult problem. D. C. Hamilton, USA

2523. Sorokin, V. S, Steady motion of a fluid heated from below (in Russian), *Prikl. Mat. Mekh.* **18**, 2, 197–204, Mar./Apr. 1954.

Solutions of nonlinear equations describing steady-flow convection are examined for a fluid that fills a closed vessel and is heated from below. It is shown that when the temperature gradient does not exceed a certain critical value, any fluid motion is suppressed. When the temperature gradient exceeds the critical value, there exist two solutions of steady motion, in addition to the solution of "no motion." The intensity of motion, with a temperature gradient not much in excess of the critical value, is proportional to the square root of the difference between the square roots of the Rayleigh numbers at the given and the critical conditions. The paper thus examines for a particular case the possibility of turbulence in the fluid.

Mainly from author's summary

The paper is poorly presented because author defines only a few of the many symbols used and he does not explain the physical conditions and limitations of the problem clearly and definitely. Y. R. Mayhew, England

2524. Emmons, H. W., Natural convection heat transfer correlation, "Studies in mathematics and mechanics" (presented to R. von Mises by Friends, Colleagues, and Pupils), New York, Academic Press, Inc., 232–241, 1954.

In this paper, author proposes to associate the natural convection heat transfer involving no change of phase with that under conditions where change of phase does take place; e.g., film condensation. By simple dimensional arguments, two transfer numbers have been deduced and, except numerical factors, agree with those calculated by elaborate mathematical analysis. Available data tend to confirm this conjecture.

Y. H. Kuo, USA

2525. Sugawara, S., and Michiyoshi, I., The heat transfer by natural convection in the unsteady state on a vertical flat wall, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 501–506.

Approximate solutions to the flow and temperature fields in the vicinity of a heated plane wall are developed for the unsteady-state period. The first approximation assumes heat transfer by conduction alone. A second approximation using velocities and temperature gradients defined from the first approximation may then be applied.

The results indicate that the steady-state condition is attained in the first solution in a period much less than a second. The modification realized from the second approximation is small.

Authors' conclusions state: "The time during which the natural convection becomes a steady flow is very short; the surface heat-transfer coefficient decreases with time; the larger the temperature difference between the wall and the fluid is, the more quickly and violently the convection occurs; and the surface heat-transfer coefficient decreases in the (vertical) direction as in the case of steady state." G. M. Ketchum, USA

2526. Schenk, J., A problem of heat transfer in laminar flow between parallel plates, *Appl. sci. Res.* (*A*) **5**, 2/3, 241–244, 1955.

Two-dimensional laminar flow between parallel plates with zero heat transfer at one wall and with a discontinuity in heat transfer from zero to a finite wall thermal transmissivity at a reference longitudinal position is investigated by determination of eigenvalues and eigenfunctions for the convection differential equation. Results are applied to analyzing the "entrance" effect on inside heat-transfer coefficient following the discontinuity.

N. A. Hall, USA

2527. Stine, H. A., and Wanlass, K., Theoretical and experimental investigation of aerodynamic-heating and isothermal heat-transfer parameters on a hemispherical nose with laminar boundary layer at supersonic Mach numbers, *NACA TN* 3344, 48 pp., Dec. 1954.

For calculating boundary layers, authors use instead of an integral method the well-known solutions of incompressible wedge flow which are applied to the present problem (body of revolution) by Mangler's transformation. Effects of compressibility were taken into account by using Stewartson's transformation. In experiments, three models with the same outside contour but different wall thicknesses were used, each for measuring one of the quantities: pressure distribution, recovery factor, and heat-transfer coefficient. The pressure coefficient varied only slightly within Mach range 1.97 to 3.80. Recovery factor decreased near stagnation point to 0.82 from the value of 0.84 at constant pressure flow. The local heat-transfer coefficients as measured are in approximate agreement (deviations $\pm 18\%$) with theoretical values of authors. H. Schuh, Sweden

2528. Rendel, D., Thermal problems of high performance flight, *Aircr. Engng.* **24**, 305, 220–223, July 1954.

2529. Schenk, J., and Beckers, H. L., Heat transfer in laminar flow between parallel plates, *Appl. Sci. Res.*(*A*) **4**, 5/6, 405–413, 1954.

An extension of previous work [AMR **4**, Rev. 3061; **6**, Rev. 548], this paper considers the problem of asymmetrical linear temperature gradients for laminar flow between parallel plates. The solution requires the odd eigenfunctions for the partial differential equation

$$\frac{3}{2}\,\mathrm{Pe}\,(1 - 4\xi^2)\,\frac{\partial\theta}{\partial\zeta} = \frac{\partial^2\theta}{\partial\xi^2}$$

with the boundary conditions $\mathrm{Nu}\ \theta = \mp\partial\theta/\partial\xi$ at $\xi = \pm\frac{1}{2}$, $\theta = 2\xi$ for $\zeta = 0$. The first three odd eigenfunctions are tabulated for $\mathrm{Nu} = \infty$, $\xi = 0(.05).50$ and the first for $\mathrm{Nu} = 0, 4$ and $\xi = 0(.05).50$. The results are applied to an examination of thermal entry effects and the behavior of the transmission Nusselt numbers. N. A. Hall, USA

2530. Konakov, P. K., Some laws of heat exchange by radiation (in Russian), *Izv. Akad. Nauk SSSR Otd. tekn. Nauk* no. 12, 1847–1855, Dec. 1953.

Author deals with a few examples of heat exchange, including absorption of the transmitting medium by using the concept of radiation energy vector and the vector calculus.

Y. R. Mayhew, England

2531. Campbell, G. J., Radiant panels for tin reflow, ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Pap. 55—S-22, 11 pp.

2532. **Monchick, L., and Reiss, H., Studies of evaporation of small drops,** *J. chem. Phys.* **22,** 5, 831–836, May 1954.

The rates of evaporation of small droplets of diameter 1 sebecate (average radius $R \sim 10^{-4}$ cm) were measured in a Millikan oil-drop chamber and observed to obey a law of the form $dR/dT = a/(1 + bR)$ which has been predicted by the theories of Fuchs, and Frisch and Collins. Using a nonequilibrium distribution function of the velocities, the relationship has been rederived in a more rigorous fashion (over a limited range of conditions). Certain corrections in the constants a and b are introduced, and the validity of the Fuchs theory in this range of conditions is demonstrated. Using the formulation of Frisch and Collins, the law may be derived in the same form, subject to certain approximations.

An empirical form of the Stokes-Cunningham law for the limiting velocity of fall in a dilute medium has been obtained for dicapryl sebecate in air.

From authors' summary by D. B. Spalding, England

2533. **Karetnikov, Yu. P., Study of heat losses to the layer of boiling liquids** (in Russian), *Zh. tekh. Fiz.* **24,** 2, 193–199, Feb. 1954.

2534. **Kobayasi, K., A study on the evaporation and combustion of a single droplet (1st Report: Surface temperature of evaporating droplet and its measurement)** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **20,** 100, 826–831, 1954.

In the present paper an attempt is made to find the surface temperature of an evaporating droplet, theoretically and experimentally.

The measurement was done, eliminating the effect of the thermocouple by the extrapolation of the relation between the apparent surface temperature and the length of the thermocouple which was a fine copper-constantan wire with a droplet of 1–2 mm in diameter on its one contact point and with a cooling jacket around another contact point being kept at the same temperature as that of the droplet surface.

The theoretical values are compared with the measurements, and some considerations on the difference between them and also on the results are stated. From author's summary

2535. **Badger, W. L., and Lindsay, R. A., Evaporation,** *Indust. Engng. Chem.* **47,** 3, part II, 532–535, Mar. 1955.

Tenth annual review.

2536. **Gluckert, F. A., Drying,** *Indust. Engng. Chem.* **47,** 3, part II, 527–531, Mar. 1955.

Tenth annual review.

2537. **Sugawara, S., and Michiyoshi, I., Dropwise condensation,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 289–292.

Heat-transfer equations for dropwise condensation are derived, but the predicted coefficients are lower than experiments of Fatica and Katz [*Chem. Engng. Prog.* **45,** 661–674, Nov. 1949]. Authors extend the Fatica and Katz equations to the case of sliding and coalescing drops on short vertical surfaces.

A. C. Mueller, USA

2538. **Codegone, C., Common thermometer used as "Kata-thermometer" (radiation thermometer)** (in Italian), *Termotecnica* 8, 11, 649–650, Nov. 1954.

In terms of human comfort, room temperature of significance includes air temperature t_a and mean radiation temperature t_r of walls. For persons at rest in quiet air, significant temperature is $t_m = (2t_a + 3t_r)/5$. Temperature t_a is given by dry bulb sling thermometer; $t_r = t_1 - (\mu/\nu)(t_a - t_1)$ where t_1 is reading of thermometer at rest, $\mu = h_c(S/M)$, $\nu = h_i(S/M)$, h_c and h_i, heat transfer coefficients by convection and radiation, respectively; S is surface area of bulb; M mass of bulb. By observing rate of cooling of bulb from moderately higher temperature (obtained by heating in palm of hand) to temperature t_1, one can calculate values of μ and ν based on relationship $-dt/d\tau = h_c(S/M)(t - t_a) + h_i(S/M)(t - t_r)$, where τ is time in same units as h_c and h_i are measured. Values of h_c and h_i are calculated from accepted relationships for heat transfer by natural convection and by radiation, respectively.

For spherical bulb 1-cm diameter in still air, value of $\mu/\nu = 2.0$. Smaller bulb gives larger value of μ/ν, but even at value of 2.5 (for considerably smaller bulb) value of t_r is not greatly changed. Mercury, alcohol, or naphtha thermometers have about the same values of μ/ν because of the closeness of volume heat capacities. D. Aronson, USA

2539. **Verhoeven, A. C., Glass thermometers** (in Dutch), *Ingenieur* **66,** 49, 0.91–0.94, Dec. 1954.

After a short survey of the history of glass thermometers, a more detailed description is given of the modern mercury thermometers with their advantages and disadvantages, as well as the errors and corrections. These errors are both dependent on external conditions and on the thermometers themselves. Finally, attention is given to other types of liquid thermometers and to the standardization of mercury thermometers.

From author's summary

2540. **Van Kuyk, H. J. L., Resistance thermometers and thermocouples** (in Dutch), *Ingenieur* **66,** 49, 0.95–0.102, Dec. 1954.

A detailed description is given of resistance thermometers, thermistors, and thermocouples as to the materials, construction, ranges, properties, and limitations. Modern developments are discussed and a mutual comparison is given.

From author's summary

2541. **Remfry, J., Heat transfer and pressure loss for air flowing in passages of small dimensions,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2638, 56 pp., 1954.

The report is prepared from a thesis presented at the University of London, 1947, for the purpose of publication. At the time the investigation was begun, not much was known about heat transfer and pressure drop in passages of cross sections different from round tubes, and particularly in the range of Reynolds numbers corresponding to the transitional region.

The investigation deals primarily with experimental determination of heat transfer and pressure drop characteristics for air flowing in small triangular, square, hexagonal, and round passages and also in waved passages and outside a nest of hexagonal tubes. The heat interchanger models, with a frontage 6 in. square, each comprised from just under 150 to over 2250 passages, according to their size and spacing. The hydraulic diameter of the smallest tubes was about 0.08 inch.

The influence of variation of passage length, pitch, and end shape was likewise examined.

By a simplified theoretical analysis, the components of total pressure drop due to friction, increase of momentum, turbulence, and end losses were separated in order to determine the "useful" friction and the relation between heat transfer and pressure loss.

Investigation showed that heat transfer in small smooth passages was less than that for turbulent flow in tubes of larger sizes and that there was a tendency toward a prolonged transition.

Further, the losses were found to be represented with good accuracy by coefficients, which may confidently be used to predict the pressure drop in similar types of passages when the rate of heat transfer is known.

Certainly such work has been partly carried out since at other places. The report, however, presents the results from a very extensive and thorough investigation and the material is presented in a form which, in the opinion of the reviewer, makes it very valuable for engineering use. C. E. Lenngren, Sweden

2542. Taylor, G. I., Diffusion and mass transport in tubes, *Proc. phys. Soc. Lond.* (*B*) **67,** 420B, part 12, 857–869, Dec. 1954.

A discussion is presented of the physical processes involved in the dispersion of soluble matter which is introduced into a solvent flowing in a straight pipe. In the situations treated, the dispersion involves the variation in fluid velocity over the cross section of the tube and the radial diffusion, the latter being due to molecular agitation or turbulence, depending upon the nature of the flow. Experiments are discussed. Agreement with theory is very good. Dispersion measurements are suggested as a means of measuring diffusion coefficients. Comparisons are made with measurements in very long pipelines.

The stability of solutions in vertical tubes when the density increases upward and the effect of radial diffusion are discussed. Measurements of the equilibrium density gradient may be used as another method of determining diffusion coefficients.

The mathematical analysis of the problems discussed in this paper is presented in *Proc. roy. Soc.* (*A*) **219,** p. 186; **223,** p. 446; **225,** p. 473. G. W. Morgan, USA

2543. Wilke, C. R., Mass transfer, *Indust. Engng. Chem.* **47,** 3, part II, 658–664, Mar. 1955.

Third annual review.

Combustion

(See also Rev. 2534)

2544. Zabetakis, M. G., and Richmond, J. K., The determination and graphic representation of the limits of flammability of complex hydrocarbon fuels at low temperatures and pressures, Fourth Symp. (International) on Combustion, 121–126, 1953; Baltimore, Md., Williams & Wilkins.

Experimental flammability limits of two aviation gasolines and two jet fuels are presented. Conditions were: (a) fixed temperature and concentration of diluting atmosphere, varied pressure; (b) fixed temperature and pressure, varied diluting atmosphere; and (c) (for the jet fuels only) saturated limits of flammability as a function of pressure for fixed diluting atmosphere. Variability of the pressure limit from about 1 to 4 mm Hg, depending on ignition source, led to design of a standard igniter and means for measuring its energy output. Design of the mixing and combustion apparatus for the low pressure, low temperature work is given and emphasis placed on care required in handling the test liquids to avoid premature evaporation. In experiments of type (b), carbon dioxide diluent was more effective than nitrogen in limiting flammability. Type (c) experiments are valuable for, among other things, serving as one criterion of the relative safeness of different fuels.

W. P. Jensen, USA

2545. Grumer, J., and Harris, Margaret E., Temperature dependence of stability limits of burner flames, *Indust. Engng. Chem.* **46,** 11, 2424–2430, Nov. 1954.

Fundamental research on the performance of fuels on gas burners has been extended in this paper to include the effect of initial temperature of the unburned gas on flame stabilization. The problem is of practical concern since most burners operate hot. It is shown that the room temperature values of critical boundary velocity gradients for flashback and blowoff are related to those for hot burners by theoretical equations involving the unburned gas temperature, the flame temperature, and the lowest temperature in the primary combustion zone. The last temperature is presently obtained empirically from data on variation of flashback and blowoff gradients with unburned gas temperature. Experiments have included flames of methane and propane. From authors' summary by E. C. Wilkerson, USA

2546. Layzer, D., Theory of linear flame propagation. Part I. Existence, uniqueness, and stability of the steady state, *J. chem. Phys.* **22,** 2, 222–229, Feb. 1954.

A set of equations is developed to describe the steady adiabatic, one-dimensional propagation of a single reaction flame. These equations assume a steady state of flame propagation, and thermal diffusion is ignored. A microscopic description for thermal conductivity and viscosity and diffusion is made, however, and shown to be valid for flame speeds below the speed of sound.

The theory predicts that arbitrarily dilute mixtures can support stable steady deflagration waves. This conclusion, which is contrary to observed fact, drastically lessens the value of the whole paper in this reviewer's eye. J. H. Davidson, USA

2547. Layzer, D., Theory of linear flame propagation. Part II. Structure of the steady state, *J. chem. Phys.* **22,** 2, 229–232, Feb. 1954.

Quantitative expressions are derived for flame speeds, and effects of fluctuations of temperature and concentration on flame structure are examined. Here again the theory is not born out of experiment. J. H. Davidson, USA

2548. Simon, D. M., Diffusion processes as rate-controlling steps in laminar flame propagation, Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953, 32 pp.

This is an excellent review and discussion of the available evidence concerning the rate-controlling mechanism of a laminar flame. After extensive investigation of the papers dealing with diffusion as the rate-controlling step as well as those proposing thermal conduction, author concludes the balance to be about even. Two pieces of experimental evidence, however, seem to tip the scales slightly in favor of the diffusion process. These are: (1) In systems not containing hydrogen, the increase in burning velocity with the addition of hydrogen agrees better with the diffusion theory; and (2) changes in burning velocities caused by the interchanging of argon for helium as diluents are closer to the diffusion theory prediction.

Flame properties other than burning velocities, quenching distance and minimum ignition properties such as structure, limits of flammability are also reviewed but are shown to offer no further conclusive evidence. The greatest faith for further work is placed in the microstructure of flames.

An extensive bibliography is given and the paper is recommended as a review of recent literature on burning velocity and other flame parameter work and rate-controlling theories for laminar flames. J. H. Davidson, USA

2549. O'Neal, C., Jr., Effect of ammonia addition on limits of flame propagation for isooctane-air mixtures at reduced pressures and elevated temperatures, *NACA TN* 3446, 32 pp., Apr. 1955.

Limits were determined for isooctane, ammonia, and mixtures of these two fuels with air at pressures up to 400 mm Hg and tem-

peratures from 60 to 400 C. In the ternary mixtures, NH_3-air weight ratios were 0.020 and 0.039. For all mixtures, the flammable region (rich minus lean limit equivalence ratio) broadened as the temperature was raised. The flammable region of isooctane was roughly three times that of ammonia. However, small additions of ammonia to isooctane broadened the flammable range up to an NH_3-air ratio of about 0.02; further additions narrowed the range. Added ammonia was completely consumed in lean mixtures; in rich mixtures about half of the ammonia was unburned. From author's summary

2550. **Koga, T., and Takao, K., A study on the hydrodynamical behaviours of chemically unstable gases (combustion gases),** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 371–375.

Authors derive hydrodynamic equations for the expansion of a chemically reactive gas together with the differential kinetic equations describing the change in composition with time. The idealized reaction $2CO_2 \rightleftharpoons 2CO + O_2$ is taken as an illustrative example and the equations are linearized by assuming that the deviation from chemical equilibrium is small. The equations are then solved by approximate numerical methods, and the variations of gas velocity, density, temperature, and pressure through a nozzle of arbitrary profile are shown graphically for the cases of no reaction, chemical equilibrium, and six arbitrarily assumed reaction rates. The results for the finite reaction rates chosen do not differ appreciably from those for the equilibrium case.

Reviewer found it impossible to follow some of the approximations made in linearizing the equations, partly because of the omission of many steps in the argument and partly because of the number of subscripts used and omitted.

For other papers on the same subject see AMR **4**, Revs. 2139, 4536; and *J. Amer. Rocket Soc.* **21**, 6, p. 179, 1951.

G. K. Adams, England

2551. **Burgoyne, J. H., and Weinberg, F. J., Determination of the distribution of some parameters across the combustion zone of a flat flame,** *Proc. roy. Soc. Lond.* (*A*) **224**, 1158, 286–308, July 1954.

Author describes an elegant method for the study of transport processes in the flame of a flat flame burner. Distribution of refractive index perpendicular to a plane flame front is determined by measuring the deflection of a light beam. Temperature distribution so determined is used with accurately measured values of the initial gas temperature, burning velocity, and approximate radiative heat transfer to determine the distribution of energy transfer by different processes, energy per gram of mixture, and the heat released and rate of heat release through the flame front. A survey of possible errors shows they are calculable or negligible for lean flames and a relatively thick flame front.

Results are given for a very lean ethylene-air flame with a 5-mm reaction zone. A sharp peak is found in the reaction rate near the peak temperature. E. O. Baicy, USA

2552. **Prigg, J. A., Aerated burners,** *Gas World* **141**, 3680, 580–584, Feb. 1955.

2553. **Nishiwaki, N., and Haghi, S., On the evaporation and the ignition lag of fuel droplets (2nd Report),** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 495–500.

2554. **Golovina, E. S., Gas formation following burning of coal dust layers** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 10, 1444–1451, Oct. 1953.

2555. **Hansen, K., Studies of fly ash, cinders, and dust collectors in connection with stoker-fired boilers** (in Danish), *IngenVidensk. Skr.* no. 1, 162 pp., 1953.

2556. **Widell, T., Gas turbines for solid fuels** (in Swedish), *Tekn. Tidskr.* **85**, 11, 229–234, Mar. 1955.

2557. **Broman, G., Ramjets** (in Swedish), *Tekn. Tidskr.* **85**, 7, 121–128, Feb. 1955.

Acoustics

(See also Rev. 2377)

2558. **Richardson, E. G., Absorption and velocity of sound in vapors,** *Rev. mod. Phys.* **27**, 1, 15–25, Jan. 1955.

Well-organized review of attenuation and velocity of sound in gases and vapors complements that of Markham, Beyer, and Lindsay [title source, **23**, p. 353, 1951], mainly on liquids. Author describes techniques and gives results.

M. Greenspan, USA

2559. **Van Itterbeek, A., Van den Berg, G. J., and Limburg, W., Apparatus to measure the velocity of sound down to liquid helium temperatures with the optical method,** *Physica* **20**, 5, 307–310, May 1954.

Ultrasonic sound transverse to the cryostat forms a diffraction grating. The velocity of sound transmission V is calculated from

$$V = kf\nu\lambda/d_k$$

where d_k is the half distance between two diffraction maxima of order k when using light of wave length λ; f is the focal distance from the screen to collimating lens; ν is the ultrasonic frequency. The apparatus is described briefly. Some results are quoted for liquid hydrogen temperatures. W. Band, USA

2560. **Fry, W. J., and Fry, Ruth B., Determination of absolute sound levels and acoustic absorption coefficients by thermocouple probes—Theory,** *J. acoust. Soc. Amer.* **26**, 3, 294–310, May 1954.

Intensity of progressive sound waves in liquids can be measured by temperature rise in a small probe of material having same characteristic impedance as liquid but much greater absorption. Present device differs from previous ones in that acoustic signal is gated and initial time rate of change of temperature is measured during pulse. Paper considers effect upon calibration of heat capacity and conductivity of thermocouple wires; temperature dependence of acoustic properties of liquid; and heat produced by friction at thermocouple wires. Results are summarized in a series of formulas for design and for estimating errors. V. Salmon, USA

2561. **Fry, W. J., and Fry, Ruth B., Determination of absolute sound levels and acoustic absorption coefficients by thermocouple probes—Experiment,** *J. acoust. Soc. Amer.* **26**, 3, 311–317, May 1954.

This is a companion to previous paper on theory (see preceding review). Probes tested used 0.0005-in. copper/constantan or iron/constantan couples in castor oil contained in disk-shaped capsule of 0.003-in. polyethylene. Acoustic intensities at 980 kcps were measured with probe and by radiation pressure method. Results agreed within experimental error. V. Salmon, USA

2562. Gavreau, V., and Miane, M., Note on the radiation pressure and the nonisotropic nature of acoustic pressure of great intensity (in French), *C. R. Acad. Sci. Paris* **238**, 22, 2148–2150, May 1954.

2563. Hasimoto, H., Rayleigh's problem for a cylinder of arbitrary shape, *J. phys. Soc. Japan* **9**, 611–619, 1954.

Paper deals with the motion of an incompressible viscous fluid generated by an infinite cylinder moving impulsively from rest. For arbitrary section, the problem is reduced to that of circular cylinder by conformal mapping. Asymptotic expressions, such as stream function in the vicinity of the cylinder, and drag are derived. A paper by Batchelor treats the same subject but by a different method [*Quart. J. Mech. appl. Math.* **7**, 179–192, 1954]. Y. H. Kuo, USA

2564. May, J. E., Jr., Characteristics of ultrasonic delay lines using quartz and barium titanate ceramic transducers, *J. acoust. Soc. Amer.* **26**, 3, 347–355, May 1954.

Previous analysis of the equivalent circuit for the ultrasonic delay line was applied to quartz crystal transducers and a vitreous silica delay medium. The analysis has been extended to evaluate the use of other materials such as magnesium, aluminum, and steel, and to include $BaTiO_3$ ceramic transducers. Calculations show the decrease in loss to be expected as the impedance of the delay medium is decreased and, conversely, the increase in band width to be expected as the impedance of the delay medium is increased. The increase in band width resulting from symmetrical loading of the transducers is also evaluated. Modifications to the equivalent circuits for the case of $BaTiO_3$ ceramic transducers are considered. Theoretically, losses can be reduced to 10 db or less, using the ceramic transducers with a vitreous silica medium. The band width is slightly less than for quartz crystal transducers. However, by utilizing higher impedance materials, band widths approaching 100% should be achieved. From author's summary

2565. Mellen, R. H., Ultrasonic spectrum of cavitation noise in water, *J. acoust. Soc. Amer.* **26**, 3, 356–360, May 1954.

The acoustic noise spectrum associated with the collapse of transient cavities produced by a stirring rod in water was measured in the frequency range 1–3500 kc. While the spectrum, in general, goes as f^{-2} above 1 kc, flat regions are found between 20 kc and 100 kc, and again above 500 kc to at least 3500 kc. If the flat regions are due to discrete random impulses, two time constants $\tau_1 \simeq 10^{-6}$ second and $\tau_2 < 10^{-4}$ second, may be obtained by using the criterion $2\pi f\tau \simeq 1$, where f is the -3 db point beyond the flat region.

With intense cavitation, the acoustic level falls off and becomes erratic in the 600-kc region. Transmission measurements made through the cavitating volume show strong sound absorption, which appears to be caused by a cloud of small stable bubbles. From author's summary

2566. Koidan, W., An acoustic method for the measurement of vibration amplitudes, *J. acoust. Soc. Amer.* **26**, 3, 428–433, May 1954.

2567. Curtis, G. C., Nomograms for the solution of the sound-ranging problem in a plane, *Quart. J. Mech. appl. Math.* **7**, part 2, 129–135, June 1954.

Nomograms are devised for locating a source of sound in the plane defined by three collinear receivers and the source, given the time of arrival of the sound at the receivers. The time of emission of the sound also results from the calculations. The advantage of the method is discussed for cases in which more than three receivers are available and the solution becomes overdetermined. M. A. Heaslet, USA

2568. Fehr, R. O., and Wells, R. J., Noise reduction of machinery and vehicles, *Noise Control* **1**, 1, 30–39, Jan. 1955.

2569. Bonvallet, G. L., and Potter, S. M., Measurement techniques for special noise problems, *Noise Control* **1**, 1, 46–53, Jan. 1955.

Ballistics, Detonics (Explosions)

(See also Revs. 2487, 2488)

2570. Popoff, K., The main problem of exterior ballistics in the light of modern mathematics [Die Hauptprobleme der äusseren Ballistik im Lichte der modernen Mathematik], 2nd ed. (Mathematik und ihre Anwendungen in Physik und Technik, Bd. 11), Leipzig, Akademische Verlagsgesellschaft Geest & Portig K.-G., 1954, xv + 277 pp., 20 figs.

This volume, although nothing on the chief title page so suggests, is a second edition of a work, undated but actually appearing in 1932. The present volume consists of three parts: I. The motion of a point in an atmosphere with constant density, (pp. 11–137); II. The motion of a point in an atmosphere of variable density (two density laws are considered) (pp. 138–211); III. The motion of the projectile about its centroid (pp. 212–274). The first two parts, here reproduced without any alteration, constituted the first edition, while the third part is new. Throughout the entire work the trajectory is assumed to be plane and the differential equations exact, with an analytic (but unidentified) drag function. The author is especially interested in treating the ballistic equations by general mathematical methods and therefore studies power series expansions, series solutions of integral equations, singularities for $v = \infty$, $y' = \infty$, $z = \infty$, etc. Part III examines precession and nutation, but no effects of lift or kiting. Stability is only touched upon. The need for further aerodynamic research, and the difficulties incident thereto for the actual velocities experienced, are emphasized in a fitting manner. The fact that the temperature of the air is not constant with altitude is ignored, nor are shock waves mentioned. The author's interests lie not in the direction of practicable procedures for constructing a firing table, but in manipulating various forms of an idealized set of ballistic equations to arrive at formally convergent solutions. A. A. Bennett, USA

2571. Cox, R. N., The optimum design of supersonic fin-stabilized sub-projectiles, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, 135–150.

Paper presents an analysis of aerodynamic design considerations for sabot-fired fin-stabilized projectiles. Speed range considered is primarily from $M = 2$ to $M = 10$. Fin span is limited by diameter of gun barrel from which projectiles are launched. Consideration is given to tail and body moments for cone-cylinder and ogival bodies and for multiple fin arrangements.

It is shown that the maximum body diameter may vary from about 0.4 to 0.5 of the bore depending upon the number of fins. In general, eight fins are considered to be the maximum number which may be used without serious loss of tail efficiency. If a positive margin of static stability of 10% is required, the body diameter is reduced by about 20%. M. J. Thompson, USA

2572. **Arons, A. B., Underwater explosion shock wave parameters at large distances from the charge.** *J. acoust. Soc. Amer.* 26, 3, 343–346, May 1954.

Experimental observations of peak pressure, decay constant, and energy flux for TNT and pentolite are presented to ranges (in feet) defined by $R \cong 2000W^{1/3}$, where W is charge weight in pounds. Previously published results extended only to $R \cong 30W^{1/3}$. From author's summary

Soil Mechanics, Seepage

(See also Rev. 2402)

2573. **Boothe, W. A., Gray, R. T., and Horvay, G., Vessels partially supported by soil,** *Proc. Amer. Soc. civ. Engrs.* 81, Separ. no. 677, 12 pp., Apr. 1955.

See AMR 7, Rev. 2788.

2574. **Laboratory analysis of soils—grain size and liquid limit: Wintermyer, A. M., and Kinter, E. B., Dispersing agents for particle-size analysis of soils; Chu, T. Y., and Davidson, D. T., Deflocculating agents for mechanical analysis of soils; Olmstead, F. R., and Johnston, C. N., Rapid methods for determining liquid limits of soils,** *Nat. Res. Counc. Highway Res. Bd. Bull.* 95, 37 pp., 1955.

2575. **Oshima, N., Fundamental equations of equilibrium in deformation of a granular medium,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 5–8.

This is a very general paper on the forms of the equations that will satisfy the conditions of equilibrium and motion in a granular medium. The assumption is made that there are a number of small regions with ordinary elastic constants and that discontinuities occur at the boundaries of these regions. By introducing methods of averaging the variables, it is shown that equivalent values of elasticity and friction exist for the medium. The equations of motion for an isotropic medium are derived. No specific cases are considered. W. P. Mason, USA

2576. **Inoue, N., Discontinuous solutions in soil mechanics,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 23–27.

Two-dimensional plastic flow can be specified by three equations, i.e., two stress equilibrium conditions and a yield condition. The three equations can be interpreted as specifying the two-dimensional ultrasonic flow of a hypothetical gas with anomalous but simple properties. This analogy is extended so that the study of shock waves can be used for discontinuities in plastic flow. R. Eisenschitz, England

2577. **Kobori, T., On relaxation and thixotropic phenomena in the vibrating soft ground,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 363–366.

Ground which is stressed cyclically has stress-strain relation which is a function of time, so that instantaneous strain depends on previous stress history. Assuming a particular stress-strain law, the following problems are treated: (a) Forced vibration of rigid body supported on ground; (b) vibration and buckling of a pile; (c) one-dimensional wave propagation.

No numerical values for ground relaxation times or other constants are given. D. C. Johnson, England

Micromeritics

(See Revs. 2402, 2555)

Geophysics, Meteorology, Oceanography

(See also Rev. 2285)

2578. **Reuter, H., Methods and problems of weather forecasting [Methoden und Probleme der Wettervorhersage],** Wien, Springer-Verlag, 1954, viii + 161 pp., 46 figs. $5.25.

Author states in preface his intention to emphasize recent studies in following areas: interaction of pressure fields aloft and at surface; toward a three-dimensional view of atmosphere; aspects of dynamic meteorology directly applicable to forecasting; objective forecast methods, especially by numerical integration of hydrodynamic equations. Resulting book definitely fills a gap in the literature. Reviewer welcomes the attempt to bring together methods of various "schools" of forecasting and considers author's effort a successful one.

Opening chapter gives principles for analysis of synoptic charts and wind profiles. Kinematic formulas of Petterssen are discussed in detail (chap. 2). Theory of quasi-stationary pressure systems (Rossby, Riehl) is used to introduce steering principles of Frankfurt school (chap. 3). Account of genesis and development of baroclinic systems relies chiefly on work of Bjerknes and of Scherhag. Results of discussions are formulated in operational rules, which total 48. Application of rules to construction of prognostic charts is illustrated by a particular example (chap. 4). Perhaps most valuable chapter (5) is that presenting in simplest possible mathematical terms numerical forecast models and methods, including synoptically applicable work of Sutcliffe and Fjörtoft, as well as that of the Princeton group. Book closes with a brief discussion of forecasting of weather elements: wind, temperature, and hydrometeors. Bibliography is selective, comprising 73 items, all referred to in text. Statistical methods of forecasting are not mentioned; reviewer forecasts inclusion of these to be a major modification of second edition.

Although treatment is not broad enough or deep enough to serve as reference for research meteorologists, it would be highly desirable to place such a book as this in the hands of students and practicing forecasters. Unfortunately, German language and high per-page price limit its accessibility to this group.
M. Wurtele, USA

2579. **Rogers, M. H., The forced flow of a thin layer of viscous fluid on a rotating sphere,** *Proc. roy. Soc. Lond.* (*A*) 224, 1157, 192–208, June 1954.

To compare results with the general circulation of the atmosphere, author considers a simplified model, consisting of the region between two concentric spheres occupied by an incompressible fluid, the outer one being treated as a free surface. Heat transport is assumed to be entirely due to conduction. The temperature field, obtained in terms of Legendre polynomials, then defines the density. The motion is then split into two parts; a basic zonal flow of solid rotation, and a smaller flow relative to the earth's surface. The relative flow is solved at first by omitting all nonlinear inertia terms except the Coriolis force, and expanding in ascending powers of the ratio of the atmosphere thickness to earth's radius. The result is shown to be reasonable except near the equator. In a second approach, the nonlinear terms are retained, and the solution is sought by expanding in ascending powers of the Rossby number (ratio of max relative zonal flow to the equatorial velocity of the earth). With three terms, a numerical example is given, showing qualitative agreement with known patterns. Author also mentions that, in the numerical

example, eddy viscosity must be used in order to predict the easterlies near the equator. The difficult question of stability of the zonal flow is not discussed. S. F. Shen, USA

2580. Hirono, T., and Usami, T., Stress in an infinite medium around a spheroidal cavity applied with hydrostatic pressure, *Pap. Meteor. Geophys.* **5**, 1, 64–88, Apr. 1954.

Hypothesis that earthquakes arise through pressure from magmas is mathematically investigated. Stresses and deformation energy are computed in infinite elastic medium arising from hydrostatic pressure in cavity of shape (1) prolate, (2) oblate, spheroid. Fracture is found to be most likely to occur at either of poles in case (1) and at some arc of equator in case (2). Authors consider that the most likely point of initial fracture is where curvature of cavity wall has maximum curvature. Following a mathematical analysis, discussion is given of points of interest.

K. E. Bullen, Australia

Lubrication; Bearings; Wear

(See also Rev. 2232)

2581. Hersey, M. D., and Hopkins, R. F., Viscosity of lubricants under pressure—coordinated data from twelve investigations, New York, Amer. Soc. mech. Engrs., 1954, 87 pp. $5.

This publication is the result of an extensive study of the published data on viscosity of lubricants under high pressure. Results of the 12 major experimental investigations, published prior to 1951, are analyzed and coordinated. The logarithms of the relative viscosities at various pressures are tabulated for different temperatures. The atmospheric viscosity and logarithm of the viscosity-temperature slope are included for each temperature. These tabulations facilitate comparisons of lubricants, provide convenient reference data, and provide a background for future investigations.

Data on 25 fatty oils, including 10 duplicates, 94 petroleum oils, including 4 duplicate samples, 17 compound oils, and 12 other lubricants are coordinated. The tests, lubricants, and method of coordinating the data are described. A review and discussion of various correlation methods and their application to the present data are presented. Empirical equations relating viscosity, pressure, and temperature are discussed. The bibliography is complete through 1952 and contains 198 references.

W. H. Goldthwaite, USA

2582. Kettleborough, C. F., Oil streamlines in bearings, *J. appl. Mech.* **22**, 1, 8–10, Mar. 1955.

A method is described to determine and trace the streamlines of oil flow through a loaded bearing, showing that a slight deviation of the Norton streamlines exists and the streamlines should follow the path described by Gibson. The analysis was made for a film ratio of 3.4, a load of 130 lb, and a sector pad $2^1/_2$-in. ID and $4^1/_8$-in. OD. L. M. Tichvinsky, USA

2583. Dow, R. B., An analysis of recent data on the effects of pressure and temperature on the viscosity of lubricants. Part I—paraffinic and naphthenic-base oils, First Ann. ASME-ASLE Conf., Baltimore, Md., Oct. 1954. Pap. 54—LUB-1, 13 pp.

2584. Murray, S. F., and Johnson, R. L., Effects of chemically active additives on boundary lubrication of steel by silicones, *NACA TN* 3257, 24 pp., Aug. 1954.

Conventional chemically active additives and more active compounds such as peroxide were investigated. Conventional additives were not effective, but more active materials such as the peroxide did give effective lubrication. However, all the chemically active-type additives were inferior to the solvent-type additions, such as the diesters previously studied.

From authors' summary

2585. Goodding, L. E., and Hatch, J. L., Experience with turbojet lubrication systems, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-76, 20 pp., 10 figs.

2586. Watson, F. J., Small-scale laboratory evaluation tests on synthetic lubricants, *Lubrication Engng.* **11**, 2, 86–90, Mar.-Apr. 1955.

2587. Towle, A., Some problems in lubrication and the substances called additives, *Instn. mech. Engrs. Auto. Div.*, 1–12, 1955.

Marine Engineering Problems

(See also Revs. 2278, 2408)

2588. Van Manen, J. D., Open-water test series with propellers in nozzles, *Inter. Shipbldg. Progr.* **1**, 2, 83–108, 1954.

Shrouding of conventional screw propellers by a type of nozzle invented by Kort has been used for many years to improve the propulsive efficiency of ships, particularly tugboats. Installations of such nozzles have been largely confined to European vessels; however, an increasing adoption of this system in U. S. inland waterway vessels has occurred in recent years. There have been many publications on this subject and considerable theoretical work done, particularly by Horn, Dickmann, and Amtsberg in Germany. However, there has been a lack of published data suitable for ready use by ship designers.

The Netherlands Model Basin has endeavored to remedy this situation by carrying out a systematic series of tests with model propellers and nozzles. Seven nozzle forms involving variation of length-to-diameter ratio of nozzle, camber ratio, and angle of attack of nozzle profile with respect to shaft centerline were tested. NACA airfoil profiles were used for the nozzles and Troost propellers B4-55 series for the screws.

The results of the tests were analyzed and plotted in the form of curves consistent with the conventional propeller charts. The tests covered a range of values which permit their use in the design of normal ship propulsion systems and clearly show the advantages which can be obtained by the use of such nozzles. Discussion of the additional theoretical and experimental work necessary for complete understanding of the problem is given.

Reviewer considers this to be a valuable and important contribution to the field of hydrodynamics of ship design. The work is consistent with the high standards of research carried out by Dr. Van Manen and the Netherlands Model Basin.

R. B. Couch, USA

2589. Metzmeier, E., Rectangular reinforced plate with built-in edges (in German), *Jahrb. Schiffbautech. Gesellsch.* **46**, 220–242, 1952.

A rectangular grid of frames and longitudinal girders, bent by uniform pressure, is replaced by an orthotropic plate, as had already been done in 1934 by S. Shimansky ["Bending of plates," Leningrad]. The defectiveness of the method itself was pointed out in 1947 by P. Papkovitch ["Theory of ship's structures," I, 2, Leningrad].

Author's numerical example proves how awkward would be the calculation required by this method.

J. M. Klitchieff, Yugoslavia